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Cape Double Star Results, 1900.*

(*Communicated by Sir David Gill, K.C.B., F.R.S., &c., His Majesty's Astronomer at the Cape of Good Hope.*)

The following measures of double stars, of which the great majority are due to Mr. Innes, were made with the 18-inch McClean telescope and the Repsold micrometer with bright wires. Red illumination was introduced on 1900 August 30. A few observations made in 1899 November and December are also included. New pairs found by Mr. Innes since the publication of his *Reference Catalogue of Southern Double Stars* are included. Estimates of these have been made by him at the 7-inch equatorial, and are quoted when the pair has not yet been measured with the McClean Telescope. Professor E. C. Pickering kindly communicated a list of pairs found at Arequipa, and measures of some of these have been made.

The programme undertaken is :

(*a*) The measurement of all southern pairs not yet measured. This includes the great part of those found here or found at Cordoba or Arequipa.

(*b*) The remeasurement of such of Sir John Herschel's pairs as have not been measured in the last forty years.

(*c*) The regular measurement of all southern rapid binary pairs.

(*d*) The remeasurement of pairs recently discovered but already measured elsewhere at one epoch only.

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Each pair will as far as possible be measured at least four times, in two groups of two nights each, separated by about one year. On the completion of this programme the individual observations will be published *in extenso* in the *Cape Annals*.

The observers in 1899–1900 were :—

L. ... Mr. J. Lunt. I. ... Mr. R. T. A. Innes.

A few check observations were made by—

G. ... Sir David Gill. G. J. ... Mr. G. F. Johns.

Generally each night's observation consists of four or five pointings for angle with measures of two double distances. When the observations are reduced and it is found that the two nights' results are not in fair agreement, the star has, when possible, been remeasured on a third or even fourth night. All stars were observed close to the meridian, and an endeavour was made to make observations on different sides of the meridian.

Every measure made is used, and where the results for different nights are weighted—which has only occurred on a few occasions—attention is directed thereto. The zero of the position angle was determined on nearly every night of observation. The results for α *Centauri* are given separately.

No search for new pairs was undertaken, but a few were found at different times, viz.—

31 pairs with the 18-inch McClean telescope by Mr. Innes.
13 „ „ „ 7-inch Merz equatorial by Mr. Innes.
6 „ „ „ transit circle by Messrs. Cox & Pead.
2 „ were taken from photographic plates, one by Mr. Johns and one by Mr. Innes.

Several distant stars have also been added to known double stars. A considerable number of proper motions have been specially determined and will be found in the last column.

[In the first column the No. only of the Ref. Cat. is given ; the hour is to be inferred from the Right Ascension.]

Ref. Cat.	Star.	Mag.	1900. R.A. h m	1900. S.D. ° ′	Epoch.	Angle. °	Dist. ″	Diff. of Mags.	No. of Nights.	Obs.	Remarks.
1	λ 1	8·8	0 1·0	30 53	1900·84	323·5	4·60	...	1	L.	
2	Harvard (Lac. 9721) ...	5·6	1·2	49 38	·01	177·1	5·20	4·9	2–1	I.	Many faint stars in field.
		,,	,,	,,	·86	175·9	5·46	5·9	2	L.	
New	Harvard (Lac. 9740) ...	6·4	4·0	54 34	·86	291·0	0·81	3·2	2	I.	Discovery communicated by Professor E. C. Pickering. Fine pair. p.m. insensible.
5	κ_1 Sculptoris ...	6·0	4·3	28 33	·84	274·6	1·36	...	1	L.	
7	Innes 43	6·9	5·7	73 47	·02	329·8	1·18	...	2–1	I.	
22	Innes 44	8·2	23·5	55 11	·85	245·1	0·74	0·5	2	I.	
23	*h* 3370	8·0	23·7	66 28	·86	63·7	40·0	...	2	L.	
24	Innes 177 (Lac. 113) ...	8·1	23 8	83 42	·85	17·2	1·05	0 9	2	I.	
27	β_2 Toucani ...	4·3	27·0	63 31	·36	297·9	0·76	0·2	2–1	I.	
		,,	,,	,,	·71	302·9	0·81	...	1	L.	Most difficult.
28	Lac. 130 ... AB	7·0	28·8	55 53	·85	274·0	0·51	0·3	3	I.	Innes 45.
	AB, C	,,	,,	,,	·85	248·6	6·83	...	2	I.	*h* 3376.
34	Innes 46	8·1	35·2	39 30	·61	331·4	1·95	2·3	1	I.	
		,,	,,	,,	·70	327·9	...	...	1	L.	
36	*h* 3385	8·7	36·0	41 45	·64	250·4	4·32	0·2	2	I.	Colours slightly contrasted.
	h 3390 (Lac. 187)	7·0	38·6	45 44	·85	312·3	14·1	2·5	1	I.	A yellow 4, B blue. No change since 1834·7. No material for p.m.
39	η Phenicis ...	4·5	38·9	58 1	·42	217·7	19 7	7·0	2	I.	

Ref. Cat.	Star.	Mag.	1900. R.A. h m	1900. S.D. ° ′	Epoch.	Angle. °	Dist. ″	Diff. of Mags.	No. of Nights.	Obs.	Remarks.
40	UA 64 Toucani ...	6·4	0 40·2	63 3	1900·03	69·0	2·75	...	1	G.	
		,,	,,	,,	·03	68·1	2·51	...	1	I.	
		,,	,,	,,	·36	69 6	2·45	...	2	L.	
42	Harvard (Lac. 207)	5·7	41·1	48 6	·86	308·3	14·3	7·3	1	I.	A yellow 3.
45	Innes 261 ...	7·2	43·1	29 53	·84	49 7	<0·25	...	1	I.	Very doubtful if elongated. Angle always unknown to observer. Estimated angle in 1897 = 60° ± .
		,,	,,	,,	·86	53·2	...	...	1	I.	
48	Innes 47	6·6	47·2	44 15	·74	1·0	1·10	0·5	2	I.	Both white. The p.m. is very small.
58	Innes 48	7·2	54·0	67 6	·48	332·9	0·63	0·7	2–1	I.	Both yellow.
60	Innes 49	7·0	56·3	53 7	·84	42·8	0·75	0·3	2	I.	
64	*h* 3415	7·0	59·3	41 11	·87	151·0	0 95	1·0	1	I.	
New	Harvard (Cape 1880, 416)	7·3	59 4	41 4	·86	259·6	3·65	3·0	2	I.	A yellow 3. New pair communicated by Professor E. C. Pickering.
1	β Phenicis ...	3·4	1 1·6	47 15	1899·91	18·0	1·27	...	1	G.	
	,, ...	,,	,,	,,	1900·78	18·1	1·55	...	2	L.	
6	Innes 262 ...	·7	4·1	30 9	·84	168·9	0·76	0 8	2	I.	
9	Cape 1	8·3	5·0	40 40	·67	70·9	2·12	0·8	1	I.	
	,, ...	,,	,,	,,	·78	71·9	2·30	...	2	L.	
11	C Z. 1h 152 ...	8·3	7·2	45 59	·67	70·5	2·86	0·2	1	I.	
	,, ...	,,	,,	,,	·86	68·3	3·17	...	2	L.	
New	Cape 26 ... ... (C.Z. 1h 176)	8·7	8·0	49 48	1899·8	50 ±	1 ±	0·3	1	I.	Discovered at the transit circle by Mr. W. H. Cox.

Ref. Cat.	Star.	Mag.	1900. R.A. h m	S.D. ° ′	Epoch.	Angle. °	Dist. ″	Diff. of Mags.	No. of Nights.	Obs.	Remarks.
13	Innes 27	7·3	1 11·6	69 21	1900·51	197·2	1·03	0·5	3	I.	Slight evidence of direct motion, but in κ Toucani, which is connected with this system, the motion is retrograde.
	,, ...	,,	,,	,,	·70	201·5	0·94	...	1	L.	
14	κ Toucani ...	4·9	12·4	69 24	·51	351·8	5·31	...	3	I.	
	,, ...	,,	,,	,,	·70	353·3	5·18	...	2	L.	
15	Innes 50	9·0	12·7	37 48	·85	144·3	0·85	1·0	2	I.	
22	h 3430	6·8	16·5	57 52	1899·95	237·0	2·85	...	2	I.	Companion deep yellow. Angle decreasing slowly.
26	Innes 263 ...	7·2	19·0	70 14	1900·37	60·5	0·74	0·2	2	I.	
	,, ...	,,	,,	,,	·72	63·0	0·84	...	1	L.	
New	Harvard (Lac. 388)	7 0	19·2	41 28	·86	240·5	4·47	4·3	2–1	I.	A yellow 4, B bluish. p.m. of A is $\alpha = [-0^s·01]$. $\delta = -0''·08$.
31	Innes 264 AB	8·0	27·6	53 53	·43	121·2	0·51	0·2	2–1	I.	
	,, AB, C	,,	,,	,,	·44	6·6	39·3	3·5	2	I.	
33	Innes 51	7 0	30·1	46 12	·85	13·0	1·77	2·9	2	I.	A yellowish 3, B bluish. p.m. of A = $0''·118$ towards $31°·9$.
35	τ Sculptoris ...	5·7	31·5	30 25	·89	94·2	1·96	...	2	L.	
37	p Eridani ...	5·3	36·0	56 42	·38	223·5	7·73	...	2	L.	
38	λ 15	7·8	36·4	22 13	·86	313·2	2·85	...	1	L.	
48	Innes 52	8·5	43·5	44 28	·86	181·2	0·65	0·4	1	I.	
55	χ Eridani ...	3·6	52·1	52 6	1899·96	197·6	6·24	...	2–1	I.	Common p.m.
56	h 3475	6·4	52·1	60 48	1900·11	49·6	2·61	...	1	I.	Slow increase in angle.
	,,	,,	,,	,,	·71	52·3	2·49	...	2	L.	
57	Cape 2	9·0	52·5	42 51	·68	94·8	3·28	0·5	2	I.	

Ref. Cat.	Star.		Mag.	1900. R.A. h m	S.D. ° ′	Epoch.	Angle. °	Dist. ″	Diff. of Mags.	No. of Nights.	Obs.	Remarks.
61	Innes 265	...	8·0	1 56·8	44 19	1900·86	25·4	0·79	0·7	1	I.	
5	*h* 3485 ...	...	8·1	2 7·8	49 48	·76	140·5	4·13	...	2	L.	Fixed.
7	Innes 266	...	7·6	10·4	66 37	·41	162·0	3·20	...	2	I.	A yellow, B blue.
12	*h* 3497 ...	AB	5·4	16 7	56 24	1899·96	81·5	33·3	5·1	1	I.	In *Ref. Cat.* delete "Harvard." No change since *h*.
	,,	AC	,,	,,	,,	·96	318·8	69·5	7·6	1	I.	New.
13	Innes 147	...	7·7	17·9	48 46	1900·41	339·8	1·62	...	2–1	I.	
	,,		,,	,,	,,	·70	Not seen double			1	L.	
24	Innes 53 ...	...	9·6	35·6	40 24	·10	331·0	4·09	...	1	I.	
	,,		,,	,,	,,	·86	330·4	3·54	...	1	L.	
New Cape 27 (Lac. 1884)			7·9	39·1	88 50	·99	204·3	7·46	2·0	1–2	I.	Found by Mr. G. F. Johns on photo plates. It is somewhat surprising that such an easy pair should so long have escaped notice.
31	Innes 267	...	8·0	41·8	41 39	·40	24·7	2·04	...	2	I.	
32	Innes 28 ...	...	8·5	42·1	67 42	1899·96	Single	...	...	1	I.	The only pair near here is C.G.A. 2996+7 ($2^h\ 43^m{\cdot}6 - 67°\ 25'$).
35	C.Z. 2^h 1201	AB	9·0	44·3	60 34	1900·01	251·3	0·99	...	1	I.	Innes 268.
	,,	AB, C	,,	,,	,,	·01	215·4	21·1	...	1	I.	*h* 3534.
40	γ_2 Fornacis	...	5·6	45·6	28 21	·72	Single	...	...	1	L.	
43	Cordoba (6)	...	8·5	47·3	45 39	·40	181·2	3·67	0·2	2	I.	
46	Innes 148 ...	...	7·6	52·3	63 25	·43	7·9	5·04	...	2	I.	
47	Cordoba (7)	...	8·0	52·7	39 51	·40	183·5	3·40	0·3	2	I.	
48	Innes 149	...	9·4	52·8	23 47	·10	260·2	7·28	1·6	1	I.	

Ref. Cat.	Star.		Mag.	1900. R.A. h m	1900. S.D. ° ′	Epoch.	Angle. °	Dist. ″	Diff. of Mags.	No. of Nights.	Obs.	Remarks.
50	θ Eridani	...	3·1	2 54·5	40 42	1900·79	84·9	8·21	...	2	L.	
53	h 3549 ...	...	9·4	59·2	38 27	·10	277·2	5·96	...	1	I.	
4	Cape 3 ...	...	9·2	3 4·5	42 54	·06	249·8	2·61	...	1	I.	
5	Innes 54 ...	...	8·7	5·0	41 45	·06	132·6	1·23	0·5	1	I.	
10	P. III. 19	AB	5·9	8·9	44 48	·01	182·6	0·97	0·7	1	I.	AB yellowish.
	,,	AC	,,	,,	,,	·01	210·7	3·47	...	1	I.	C bluish.
	,,	BC	,,	,,	,,	·01	220·4	2·65	...	1	I.	
New	Innes 341 (O.A. 2179)		8·5	13·6	19 26	·8	10 ±	1·3 ±	1·2	1	I.	Found with the 7-in. refractor.
20	Innes 56 ...	...	8·5	15·1	43 0	·50	256·4	3·36	2·7	2	I.	
21	Innes 150	...	8·2	15·9	63 26	1899·96	357·7	4·08	2·0	2	I.	
23	Innes 151	...	8·2	18·7	41 41	1900·95	160·4	1·23	0·3	2	I.	Both white.
27	Innes 57 ...	...	9·0	24·0	59 38	·48	210·8	2·38	1·0	2	I.	
28	Cordoba (χ_3 Fornacis)		6·6	24·3	36 12	·95	249·1	6·30	4·1	2	I.	Small star reddish. In *Ref. Cat.* delete Innes 58. Noted dpl. $6\frac{1}{2}$, 10 in Uranometria Argentina.
61	Innes 269	AB	7·3	58·7	54 41	·02	80·0	3·55	...	2–1	I.	
	,,	,,	,,	,,	,,	·03	78·5	3·99	...	1	G.	
	,,	,,	,,	,,	,,	·03	75·4	...	...	1	L.	
	,,	AC	,,	,,	,,	·03	196·0	27·8	4·7	1	I.	New.
	,,	,,	,,	,,	,,	·03	195·4	27·8	...	1	L.	
2	Russell 38	...	6·4	4 0·9	85 34	·08	245·0	2·31	...	1	L,	

Ref. Cat.	Star.		Mag.	1900. R.A. h m	S.D. ° ′	Epoch.	Angle. °	Dist. ″	Diff. of Mags.	No. of Nights.	Obs.	Remarks.
4	Innes 152	...	7·6	4 1·2	35 43	1900·10	68·0	0·92	0·0	2–1	I.	
6	Innes 153	...	7·1	4·4	33 7	·55	339·5	0·83	0·0	2	I.	Both white.
12	υ_4 Eridani	...	3·8	14·1	34 2	·06	Single	...	...	2	I.	Considered double with the 7-in. (Innes 270).
21	Innes 271	...	7·5	18·5	43 1	·09	148·1	2·45	...	2	I.	*h* 3646.
22	Lac. 1435	A, BC	7·2	18·6	41 27	·03	137·2	38·3	...	1	I.	*h* 3646.
	,,	,,	,,	,,	,,	·03	137·0	37·6	...	1	L.	
	,,	BC	,,	,,	,,	·51	191·3	1·24	1·0	2–1	I.	Innes 272.
New	Innes 384 (P. IV. 81)		6·7	19·5	35 47	·55	187·0	18·8	7·1	2	I.	Found with the 18-in McClean refractor.
23	Σ 544 ...	...	8·2	19·9	8 59	...	...	...	...	...	I.	In note in *Ref. Cat.* for "pr." read "f." (R.A. $4^h\ 19^m\ 54^s$).
26	Innes 59	AB	6 6	21·2	34 59	·09	198·0	42·4	3·4	1	I.	
	,,	BC	,,	,,	,,	·54	281·3	4·04	1·5	2	I.	
32	Innes 154	...	7·5	27·6	35 59	·55	318·5	0·61	0·1	2–1	I.	
New	Cape 28		9·1	34·1	50 21	1899·9	300 ±	3 ±	0·7	1	I.	Discovered with transit circle by Mr. J. A. J. Pead.
39	*h* 3672 ...	...	8·3	35·0	35 30	1900·54	300·2	4·48	0·7	2	I.	
43	Innes 60 ...	...	9·0	38·1	45 54	·54	96·0	2·72	0·2	2	I.	
52	Cordoba (11)	...	8·0	46·7	39 21	·58	51·8	3·91	...	2	I.	Also seen at Madras in 1865.
New	Innes 342 (Lac. 1637)	...	7·5	47·4	54 4	·22	176·5	1·11	0·6	1	I.	Found with the 18-in. McClean telescope.
,,	Innes 343 (Lac. 1641)	...	7·8	47·7	54 37	·22	45·3	2·59	3·7	1	J.	Found with the 18-in. McClean telescope.

Ref. Cat.	Star.	Mag.	R.A. 1909. h m	S.D. ° ′	Epoch.	Angle. °	Dist. ″	Diff. of Mags.	No. of Nights.	Obs.	Remarks.
54	*h* 3699	7·7	4 47·7	45 50	1900·13	142·6	18″·1	4·5	2	I.	No change in angle; *h* has 5″ ±.
56	Innes 273 ...	9·0	48·1	45 6	·54	350·6	1·27	0·1	2	I.	
61	*h* 3707	9·2	51·5	59 55	·17	269·0	8·79	3·5	1	I.	No nebula seen.
New	Innes 344 (C.Z. 4h 1849) ...	8·5	54 2	51 36	·60	21·5	1·80	2·3	2	I.	Found with the 18-in. McClean telescope.
1	Innes 274 ...	8·0	5 0 3	50 56	·03	257·0	3·27	...	1	G.	
	,, ...	,,	,,	,,	·03	257·9	3·20	...	1	I.	
	,, ...	,,	,,	,,	·05	257·7	3·18	...	2	L.	
12	κ Leporis ...	4·4	8·6	13 4	·12	359·9	2·54	...	1	L.	
14	Rigel A, BC	0·3	9·7	8 19	·18	202·9	9·36	...	1	L.	
19	Howe (C.Z. 5h 381)	8·3	11·6	29 37	·07	237·2	2·46	...	1	L.	
22	Cordoba (13) ...	8·8	14·0	27 36	·21	93·8	3·34	0·2	1	I.	
30	Peters (Bradley 757) ...	7·2	18·8	0 58	·10	167·1	2·16	...	1	L.	
34	Innes 275 ...	8·2	19·9	36 46	·15	1·7	1·62	0·5	2	I.	
New	Innes 345 (θ Pictoris) ...	6·3	22·5	52 24	·60	199·2	0·43	0·6	2	I.	Found with the 18-in. McClean telescope. As a wide pair this is Dunlop 20. p.m. in α uncertain, in δ = −0″·12.
New	Innes 346 (P.V. 122) ...	5·9	23·9	41 2	1899·9	180 ±	20 ±	6·1	1	I.	Found with the 18-in. McClean telescope.
40	*h* 3768	9·0	26·1	66 41	1900·21	...	...	...	1	I.	Nebula with star N.f. Nebula too diffused to be worth measuring as a double star.
1	Innes 276 ...	6·4	27·5	68 42	·59	212·9	0·56	0·3	2–1	I.	

Ref. Cat.	Star.		Mag.	1900. R.A. h m	S.D.' ° ′	Epoch.	Angle. °	Dist. ″	Diff. of Mags.	No. of Nights.	Obs.	Remarks.
43	Innes 62 ...	...	8·0	5 27·8	47 16	1900·59	176·9	0·81	0·4	2	I.	
52	Harvard (Lac. 1922)	...	6·6	29·6	64 0	·48	68·4	8·65	4·4	2	I.	
67	*h* 3784 ...	...	8·2	35·4	46 9	·14	60·7	5·71	...	1	L.	Common p.m. of 0″·48 towards 199°·5.
70	*α* Columbæ	...	2·7	36·0	34 8	·06	358·0	11·6	9·3	1	I.	The measure differs considerably from Prof. See's; on other occasions the companion was invisible.
	,,	...	,,	,,	,,	·32	Not seen		...	1	I.	
New	Innes 347 (Lac. 2022)	...	8·0	36·3	75 18	·11	127·2	8·99	3·0	1	I.	Found with the 18-in. McClean refractor.
72	Innes 277	...	8·0	36·6	71 12	·04	189·9	3·94	...	2	I.	A yellowish, B bluish.
77	Innes 278	...	8·5	42·6	68 45	·11	170·0	1·06	...	1	I.	
81	*h* 3802 ...	...	8·1	43·4	55 46	·05	307·8	8·05	...	1	L.	
84	Jacob (3)...	...	5·8	45·0	14 31	·12	179·6	2·57	...	1	L.	
86	Innes 63	AB	7·1	45·7	48 57	·08	11·5	1·45	...	2	I.	
	,,	AC	,,	,,	,,	·08	211·4	31·8	5·0	2	I.	A 10^{m} star S.f.
New	Innes 348 (O.A. 4412)		9·0	49·0	29 3	·3	80±	2·5±	1·5	1	I.	Found with the 7-in. refractor.
89	Innes 64	AB	5·6	49·1	37 39	·05	233·0	18·8	5·4	2	I.	
	,,	AC	,,	,,	,,	1899·98	16·1	44·9	5·9	1	I.	
95	Innes 155	AB	8·0	55·6	33 50	1900·25	18·4	1·70	...	2	I.	
	,,	AC	,,	,,	,,	·21	97·2	18·1	3·3	1	I.	New.
3	*h* 3834 ...	...	5·8	6 1·8	45 5	·14	225·8	4·06	...	1	L.	

Ref. Cat.	Star.		Mag.	1900. R.A. h m	1900. S.D. ° ′	Epoch.	Angle. °	Dist. ″	Diff. of Mags.	No. of Nights.	Obs.	Remarks.
9	Innes 280 (C.Z. vi. 263)		9·0	6 6·7	46 20	1900·08	278·0	8·70	2·5	2	I.	There is a very faint pair about 50″ N.f. Identification and note in Ref. Cat. erroneous.
	,,	...	,,	,,	,,	·10	276·5	·11	4·5	1	L.	
New	Innes 349 (Lac. 2198)	...	7·0	10·7	29·34	·32	41·4	5·82	4·0	1	I.	Found with the 7-in. refractor.
4*a*	Cape 23 ...	...	8·5	11·8	49·5	·28	62·7	...	...	1	I.	
23	Innes 281	...	8·7	17·8	44 45	·09	6·6	6·37	...	2	I.	A yellow. The p.m. of the chief star is 0″·23 towards 90°·0.
28	Innes 282	...	7·7	21·7	50 29	·06	312·5	1·85	...	1	I.	
31	G Puppis ..	...	6·0	23·1	48 7	·08	132·6	1·42	...	3	I.	B is yellowish.
	,, ...	...	,,	,,	,,	·12	136·2	...	...	1	L.	
New	Innes 350 (Lac. 2315)		7·5	26·0	45 43	·98	10·4	16·1	5·5	1	I.	Found on triple chart plate No. 5711.
40	β 754 ...	...	7·0	31·1	33 56	...	...	...	...	...	...	This pair has a common p.m. of 0″·118 towards 312°·6.
47	Innes 5 ...	...	6·6	36·9	61 27	·23	274·3	2·85	2·5	2	I.	
51	Cordoba (15)	AB	8·7	38·7	37 54	·22	277·8	4·13	1·3	2	I.	
	,,	AC	,,	,,	,,	·22	149·3	19·4	3·3	2	I.	New.
53	Innes 283	...	8·0	39·4	42 28	·18	181·4	2·62	...	2	I.	
55	Innes 179	...	6·9	41·2	30 29	·18	225·2	4·45	...	2	I.	Prof. See's angle requires + 20°.
57	Innes 284	...	8·5	41·6	64 25	·10	233·6	5·84	...	2	I.	
58	*h* 3891 ...	...	6·0	41·7	30 51	·17	225·0	5·06	...	1	L.	Prof. See's angle requires + 20°.
	,,	...	,,	,,	,,	·18	223·0	5·06	...	2–1	I.	

Ref. Cat.	Star.		Mag.	1900. R.A. h m	S.D. ° ′	Epoch.	Angle. °	Dist. ″	Diff. of Mags.	No. of Nights.	Obs.	Remarks.
New	Innes 351 (Lac. 2515)		6·9	6 42·5	71 40	1900·18	335·6	10″·7	3·1	1	I.	Found with the 18-in. McClean telescope. Another *comes* 11ᵐ·3 20° ± 40″ ±.
59	Innes 180	AB	8·5	42·5	52 19	·48	332·4	0·95	1·1	2	I.	Both white.
	,,	AC	,,	,,	,,	·48	243·1	43·5	3·0	2	I.	New.
64	Innes 157	...	7·0	44·7	54 35	·18	348·3	1·43	...	1	I.	
73	Innes 159	...	6·4	47·1	45 20	·12	324·8	6 00	...	1	I.	A orange, B blue.
75	Cordoba (16)	...	8·4	48·8	35 10	·17	110·4	2·89	...	1	L.	
83	Innes 65 ...	...	6·3	53·7	35 23	·01	184?	...	...	1	I.	Perhaps elongated.
	,,	...	,,	,,	,,	·06	184·9	0·3 ±	...	1	I.	In contact.
	,,	...	,,	,,	,,	·98	192·6	0·25 ±	...	1	I.	Elongated. Yellow 3.
10	Innes 184	AB	8·0	7 7·8	60 25	·11	175·9	0·86	0·4	3	I.	
		AC				·11	339·8	24·6	3·3	2	I.	New.
11	Hargrave 9	...	7·5	7·9	56 12	·38	221·6	1·8 ±	...	1	I.	
13	*h* 3941 ...	...	6·9	8·0	60 13	·11	302·0	1·22	0·3	3	I.	No certain change.
	Harvard (Lac. 2735)		6·0	11·1	63 1	·28	164·9	0·5 ±	...	1	I.	Bailey gives 1894·37 157°·0 0″·50 Δm = 0·3 2n.
24	τ Canis Majoris ...		4·6	14·6	24 46	·20	89·2	8·37	...	2	L.	
25	Innes 7 ...	...	7·3	14·6	46 49	·25	207·5	1·06	...	4-2	I.	Com. p.m. = 0″·588 towards 341°·7. Change of angle 7° in four years.
26	*h* 3949 ...	...	7·3	14·7	30 37	·20	77·5	2·94	...	2	L.	Very slow increase in angle.
27	Jacob (4) ...	...	9·1	15 0	36 35	·20	211·8	2·86	...	2	L.	Fixed.
28	Lalande 53	...	7·6	15·1	21 52	·06	345·4	3·97	...	1	L.	Very slow decrease in angle.

Ref. Cat.	Star.	Mag.	R.A. 1900. h m	S.D. ° ′	Epoch.	Angle. °	Dist. ″	Diff. of Mags.	No. of Nights.	Obs.	Remarks.
8*a*	Innes 312 ...	7·7	7 18 7	75 41	1900·27	169·9	1·14	0·1	1	I.	
38	λ 78	7·7	18·9	25 35	·08	288·5	2·16	1·8	1	I.	A remarkable object, very red. C = 9·0 and D = 10·0 also seen.
40	Lal. 14480 AB (β 199)	7·3	20·8	20 59	·10	21·1	2·11	...	1	L.	
	Lal. 14480 AC (Hough)				·10	116·4	7·06	...	1	L.	C = 13ᵐ·0.
New	Innes 352 (C.Z. 7ʰ 1526)	8·5	22·4	37 57	·29	20 ±	0·5 ±	...	1	I.	Found with the 7-inch.
47	Σ 1104	6·8	24·8	14 47	·10	330·9	2·14	...	1	L.	
51	*h* 3996	7·6	27·8	84 17	·08	253·8	16·0	2·4	1	I.	The p.m. is very small. *h* has 248°·4.
52	Howe 7	8·6	29·8	23 29	·10	204·4	1·85	...	1	L.	
54	Cordoba 70 (Lal. 14834)	7·0	31·1	2 56		Single		...	4	I.	This star was observed double at Cordoba on one night when meridian places of both components were secured. The pair seen here in 1898 is 2 min. pr. and is BD − 2° No. 2180 mag. 9·0, measured by L. as follows:—1900·17 148°·5 7″ 54 In.
55	Cordoba 71 (Bris. 1669)	7·7	31·1	66 58	·33	194·6	3·91	2·3	1	I.	
New	Innes 353 (Lac. 2915)	7·4	36 5	43 3	1899·9	45 ±	1 ±	0·5	1	I.	Found with the 7-inch. The p.m. is very small.
65	*h* 3997	6·1	37·4	74 3	1900·28	110 3	2·33	...	1	I.	Angle and distance increasing.
New	Innes 354 (C.Z. 7ʰ 2786)	7·5	39·4	42 20	1899·9	135 ±	1 ±	...	1	I.	Found with the 7-inch. The p.m. is nil.

Ref. Cat.	Star.	Mag.	1900. R.A. h m	1900. S.D. ° ′	Epoch.	Angle. °	Dist. ″	Diff. of Mags.	No. of Nights.	Obs.	Remarks.
12	O.Stone(O.A.8124)	8·2	8 5·5	26 50	1900·22	261·2	3·33	...	2	L.	
18	Innes 192 ...	7·7	8·7	68 42	·18	174·7	2·04	...	1	I.	
37	„ 9	6·8	15·9	73 30	·18	312·4	...	0·1	1	I.	No third star seen.
41	B Velorum ...	4·8	19·5	48 10	·18	141·5	1·23	1·0	1	I.	
...	Cordoba (Bris. 2035)	7·5	24·5	40 55	·4	110 ±	5 ±	2·8	1	I.	C.Z. 8^h 1971 mag. 9·0 is 2 sec. f. 16″ N.
50	Innes 195 ...	6·9	30·7	37 16	·25	42·4	2·31	...	2	L.	
New	„ 355 ...	8·2	31·8	20 43	·3	50· ±	0·8 ±	1·0	1	I.	Found with the 7-inch.
15*a*	„ 314 ...	6·7	35·6	36 15	·38	239·4	0·96	2 5	1	I.	
57	Harvard (Lac. 3467)	6·5	35·9	52 44	·18	294·4	22·3	...	1	I.	
					·27	294·5	cloud	...	1	L.	
...	*h* 4126 (Lac. 3476)	6·0	37·1	52 42	·26	29 8	16·7	...	2	L.	See also 16*a* in Ref. Cat.
65	δ Argûs AB ...	2·0	41·9	54 21	·19	173·2	2·46	...	4	I.	B orange yellow.
	„ „ ...	„	„	„	·28	175·3	2·05	...	2	L.	Common proper motion.
	„ AC ...	„	„	„	1899·99	62·0	69·5	...	1	I.	There is a $12^m·0$ star 240° ± 70″ ± .
	„ „ ...	„	„	„	1900·30	62·0	69·3	...	2	L.	
New	Innes 356 (C.P.D. −54°1795)	10·0	42·6	54 18	1899·99	297·1	3·04	1·0	1	I.	Found with the 18-inch McClean telescope. 36*s*. f. δ Argûs.
69	Innes 70	7 0	44·0	38 34	1900·29	114·4	1·19	2 5	1	I.	
...	*h* 4148	8·3	47·9	53 44	·26	111·4	...	...	1	L.	
19*a* (20*a*)	Innes 317 ...	8·5	51·6	43 5	·29	303·4	1·86	1 2	1	I.	No. 19*a* should be struck out (error of copying).

Ref. Cat.	Star.	Mag.	1900. R.A. h m	1900. S.D. ° ′	Epoch.	Angle. °	Dist. ″	Diff. of Mags.	No. of Nights.	Obs.	Remarks.
89	H Velorum ...	4·7	8 53·3	52 20	1900·23	343·6	2·65	...	1	L.	
	,, ...	,,	,,	,,	·30	340·7	2·56	...	1	I.	Fixed in angle, distance perhaps decreasing. B bluish.
90	Cordoba 20 (Lac. 3615)	7·5	53·5	42 52	·31	45·0	3·03	2·5	2	I.	
91	Gilliss 104 (Lac. 3648)	7·0	56·8	49 10	·31	305·1	8·97	2·7	2–1	I.	A yellow, B blue. And Innes 71 = &c. should be struck out. An $11^{m}\cdot0$ is N. pr. and an $11^{m}\cdot5$ N. f.
93	Innes 287 ...	8·0	55·1	73 40	·33	241·6	1·94	2·0	2–1	I.	
...	h 4164 (Lac. 3666)	7·5	55·8	65 49	·32	145·5	10·4	...	1	I.	The companion is C.Z. 8^{h} 4488 mag. 9·2.
21a	b_2 Carinæ ...	5·2	57·0	58 42	·31	200	29·1	...	3–2	I.	
	,, ...	,,	,,	,,	·33	187	29·2	...	1	L.	
New	Innes 357 (O.A. 9263)	8·4	57·6	23 21	·3	175 ±	0·6 ±	...	1	I.	Found with the 7-inch.
96	h 4165	5·4	58 6	51 48	·30	99·2	1·20	...	1	I.	Slow increase in angle.
97	h 4167	8·9	58 8	65 57	·31	25·2	4·35	...	2	I.	Fixed, h has 25°·1.
2	Howe 10	7·7	9 2·1	31 12	·23	307·9	3·08	...	2	L.	
3	h 4178	6·9	2·1	57 27	·31	165·6	3·44	3·6	2	I.	No change. Many faint stars about, the closest = 12^{m} is f, a little N.
4	Innes 196 ...	8·5	2·4	49 45	·29	174·3	0·69	...	1	I.	
,,	,, ...	,,	,,	,,	·30	171·3	0·80	...	1	L.	
8	Cordoba 21 (C.Z. 9^{h} 448)	8·3	6·3	43 46	·33	44·6	2·47	...	1	I.	

Ref. Cat.	Star.	Mag.	1900. R.A. h m	1900. S.D. ° ′	Epoch.	Angle. °	Dist. ″	Diff. of Mags.	No. of Nights.	Obs.	Remarks.
9	Innes 288 ...	8·2	9 6·9	74 21	1900·34	254·0	0·76	...	2	I.	
11	„ 169 ...	7·2	7·3	42 51	·34	Single	...	...	2	I.	Original record referred to. Found on the "best night I ever saw." No p.m.
22*a*	„ 319 ...	9·1	10·4	82 37	·18	84·1	4·79	1·5	1	I.	Surrounded by 4 or 5 small stars, the closest almost due S.
New	Innes 358 (Lac. 3811)	5·4	15·9	68 16	·34	131·8	18·2	6·6	1	I.	Found with the 18-in. McClean telescope. p.m. is $\alpha = -0^{s}\cdot016$, $\delta = 0''\cdot0 \pm$.
27	Lac. 3846 AB	5·4	17·6	74 28	·34	266·7	0·3 ±	1·0	1	I.	Innes 12, but rejected in the Ref. Cat, as I could not see it double with the 7-in. Estimate in 1894 = 290° ±.
„	„ AB, C	„	„	„	·34	340·7	7·05	4 6	1	I.	*h* 4206.
31	I Velorum BC	9·4	23·1	52 57	·34	35·4	3·10	1·0	1	I.	
32	Innes 199 ...	8·5	23·4	69 59	·34	318·1	2·60	...	1	I.	
40	ψ Argûs	3·5	26·8	40 2	·30	292·8	0·76	...	4–1	I.	Weighted mean. Found by Dr. Copeland. Change at present 12° ± p. an.
41	Innes 31	9·2	27·9	56 33	·34	155·4	3·21	...	1	I.	Also an $11^{m}\cdot0$ N. pr., an $11^{m}\cdot0$ S. pr. and a $12^{m}\cdot5$ S. f.
47	*h* 4220	5·3	30·2	48 34	·24	207·4	2·38	...	5	L.	Very slow increase in angle.
New	Innes 359 (Lac. 3977)	8·0	33·8	67 46	·29	172·8	1·69	3·0	1	I.	Found with the 18-in. McClean telescope.
New	Innes 360 (G.P.Z. 6364)	8·9	33·9	66 50	·29	184·8	4·92	1·0	1	I.	Found with the 18-in. McClean telescope.
75	Innes 291 ...	7·2	59·3	70 15	·22	323·7	1·18	3·0	1	I.	

Ref. Cat.	Star.	Mag.	1900. R.A. h m	1900. S.D. ° ′	Epoch.	Angle. °	Dist. ″	Diff. of Mags.	No. of Nights.	Obs.	Remarks.
14	Innes 13 AB	6 4	10 7·0	68 12	1900·26	146·7	0·90	0·2	2	I.	
,,	,, ,,	,,	,,	,,	·28	149·3	1·16	...	2	L.	
,,	,, AC	,,	,,	,,	·22	39·9	35·1	3·3	1	I.	
,,	,, ,,	,,	,,	,,	·27	40·3	...	...	1	L.	
17	Howe 13	8·3	10·3	36 9	·28	307·2	3·09	...	3–2	L.	
18	*h* 4310	7·3	10·4	83 36	·31	272·4	3·57	...	2	L.	
New	Innes 361 (C.Z. 10h 707)	8·9	10·6	47 9	·29	150 ±	4 ±	2·1	1	I.	Found with the 7-in. telescope.
35	Cordoba 23 (C.Z. 10h 1352)	7·8	19·1	65 11	·22	156·9	4·09	2 5	1	I.	
		,,	,,	,,	·30	157·5	3·86	...	2	L.	
37	Innes 209 ...	7 5	20·0	38 4	·44	137·8	1·11	...	1	I.	
38	,, 210 ...	7·7	23·4	38 12	·44	235·4	...	2·5	1	I.	
44	*h* 4329	5·1	27·5	53 12	·37	83·0	31·2	...	2	L.	Change due to p.m. of the chief star.
62	t_2 Carinæ ...	4·7	35·0	58 40	·41	20·1	14·7	...	1	L.	
66	Cordoba 25 (C.Z. 10h 2704)	8·5	38·2	44 44	·41	224·3	2·98	...	1	L.	
73	Σ 1470	8·5	41·2	5 14	·30	12·5	1·51	...	2	L.	
74	μ Argûs	2·8	42·5	48 54	·36	61·7	2 73	...	1	I.	Very slow increase in angle probable.
,,	,, ...	,,	,,	,,	·41	61·5	2·21	...	1	L.	
76	40 Sextantis ...	6 7	44·2	3 30	·30	3·0	2·27	...	2	L.	
77	δ_1 Chameleontis ...	5·5	44·3	79 55	·36	63·9	0·40	0·2	1	I.	

Ref. Cat.	Star.		Mag.	1900. R.A. h m	1900. S.D. ° ′	Epoch.	Angle. °	Dist. ″	Diff. of Mags.	No. of Nights.	Obs.	Remarks.
78	*h* 4373 ...	...	8·9	10 44·4	40 55	1900·36	344·0	10·9	...	1	I.	A yellow. Movement.
84	Innes 306	...	9·0	51·5	47 3	·36	164·3	1·14	2·0	1	I.	The p.m. is very small.
89	Σ 1500 ...	...	7·3	54·9	2 56	·30	314·2	1·68	...	2	L.	
93	Innes 212	...	7·0	58·1	81 1	·36	145·9	0·72	0·1	1	I.	Both white.
12	*h* 4423 ...	...	6·4	11 11·8	45 20	·30	277·0	2·16	...	2	L.	
20	Cape 21 ...	...	9·1	19·5	47 25	·35	286·0	3 40	...	2	L.	
29	ω_1 Centauri	...	4·9	27·1	58 53	·48	125·8	...	...	1	L.	
42	Innes 34	AB	5 1	34·9	64 51	·32	233·0	39·4	...	1	L.	The p.m. is very small.
,,	,,	AC	,,	,,	,,	·32	31·4	41·3	...	1	L.	
43	Innes 232	...	7·2	35·0	32 54	·30	162·8	2·27	...	2	L.	
46	*h* 4465 ...	...	5·0	36·7	31 57	·48	343·8	25·9	...	1	I.	
59	Innes 79 ...	...	7·8	49 8	41 50	·48	103·3	0·91	0·2	1	I.	
61	,, 80 ...	...	7·5	50 3	41 21	·48	106·9	1·46	0·0	1	I.	
3	η Crucis ...	...	4·3	12 1·7	64 3	·36	Not seen		...	1	I.	Harvard star 210° ± 30″.
8	Innes 216	...	7·5	4·6	51 14	·37	39·2	1·03	3·0	2	I.	Some faint stars near.
15	*h* 4505 ...	...	7·9	6·5	30 3	·36	269·4	9·86	...	1	I.	
,,	,, ...	...	,,	,,	,,	·48	269·1	10·6	...	1	L.	
19	D Centauri	...	5·4	8·8	45 10	·40	244·3	3·11	...	2	L.	Colours: Orange and bluish (I).
27	F Centauri	...	5·0	13·7	54 35	·38	87·2	35·9	7·0	1	I.	Angle perhaps 180° wrong, as W. H. Pickering gives 265° ± . Star too faint for good measures.

Ref. Cat.	Star.	Mag.	1900. R.A. h m	1900. S.D. ° ′	Epoch.	Angle. °	Dist. ″	Diff. of Mags.	No. of Nights.	Obs.	Remarks.
31	ζ_2 Muscæ ...	5·3	12 16·6	66 58	1900·43	131·6	32·6	5·2	2	I.	B is a red star.
33	Howe 21	7·6	17·4	33 0	·47	276·2	3·66	1·5	1	I.	
	,,	,,	,,	,,	·48	276·4	3·31	...	1	L.	
36	Innes 35 (C.Z. 12h 1236)	8·5	21·4	76 7	1899·5	150 ±	2 ±	...	1	I.	Wrongly identified in Ref. Cat.
41	α Crucis	1 0	21·0	62 33	1900·07	117·6	4·95	...	1	L.	
45	Cape 12	7·0	22·7	61 12	·49	250·8	1·89	2·0	1	I.	Angle decreases 0°·5 per an.
59	Innes 296 ...	6·7	32·8	74 49	·52	273 9	...	...	1	I.	Very poor.
61	γ Centauri ...	2·4	36·0	48 25	·49	357·3	1·50	0·1	3–2	I.	Day observations. *h*'s angles require + 180°, so that half the angular orbit has now been described. The period will, however, be over 150 years. Professor See gives 88 years, which is certainly too small.
66	Cordoba (27) ...	8·3	39·4	61 40	·51	189·6	5·00	1·5	1	I.	A orange, B bluish. Between two stars 11·0 and 11·5 mags.
67	ι Crucis	4·7	39·8	60 26	·36	34·6	26·9	...	1	I.	I's distance of 1896·6 referred to two fairly accordant single distances. The change is about accounted for by the p.m. of *ι Crucis*, viz. 0″·12 towards 150°, but the meridian observations are scanty and uncertain.
		,,	,,	,,	·48	34·3	26·9	...	1	L.	
68	β Muscæ... ...	3·3	40·2	67 34	·36	341·0	1·33	...	3	I.	
	,,	,,	,,	,,	·40	346·0	1·60	...	3–1	L.	
New	Innes 362 (β Crucis)	1·7	41·9	59 9	·52	322·2	44·4	9·8	1	I.	Found with the 18-inch McClean refractor.

Ref. Cat.	Star.	Mag.	1900. R.A. h m	1900. S.D. ° ′	Epoch.	Angle. °	Dist. ″	Diff. of Mags.	No. of Nights.	Obs.	Remarks.
77	Harvard (Lac. 5303)	5·8	12 47·4	59 47	1900·24	Not found.			1	I.	
78	Innes 297 ...	8·3	48·2	51 44	·44	249·9	1·84	1·5	2	I.	
82	Harvard (Lac. 5321)	5·6	50·1	56 18	·45	314·8	29·4	4·9	2	I.	
87	Cordoba (28) ...	8·0	52·8	70 6	·48	269·7	4·13	...	1	L.	Fixed.
New	Innes 363 (C.Z. 12h 3166)	8·5	55·1	67 19	·5	190 ±	3 ±	1·2	1	I.	Found with the 7-inch refractor.
1	*h* 4566	6 6	13 0 3	77 55	·29	228·2	30·1	5·4	1	I.	
	,,	,,	,,	,,	·33	228·1	29 6	...	1	L.	
2	*f* Centauri ...	4·9	0·5	47 56	·31	78·0	11·9	...	2	I.	Companion reddish. Fixed.
	,,	,,	,,	,,	·33	80·5	11·8	...	1	L.	Companion not red. Fixed.
3	ξ_2 Centauri ...	4·4	1·1	49 22	·24	100·6	25·6	...	1	I.	Common proper motion.
	,,	,,	,,	,,	·33	100·5	25·0	...	1	I.	Common proper motion.
10	Harvard (Lac. 5409)	6·4	5·0	69 26	·43	279·5	30·8	4·6	2	I.	No nearer star seen.
11	Cordoba (72) ...	8·0	5·4	46 45	·24	276·4	3·43	...	1	I.	
	,,	,,	,,	,,	·35	277·7	3·55	...	1	L.	
1	Innes 310 ...	8·7	5·8	76 56	·43	37·6	2·11	1·2	2	I.	The brightest of neighbourhood.
26	J Centauri ...	4·6	16·2	60 28	·42	...	...	...	2	I.	Very rich region but no *comes* within 20″.
29	*h* 4580	6·6	17·1	48 2	·40		Single.		2	I.	Perhaps a suspicion of elongation 33° on one night. The p.m. is insensible.
	,, ...	,,	,,	,,	·33		,,		1	L.	

Ref. Cat.	Star.	Mag.	1900. R.A. h m	S.D. ° ′	Epoch.	Angle. °	Dist. ″	Diff. of Mags.	No. of Nights.	Obs.	Remarks.
32	Cordoba (30) ...	7·0	13 19·1	51 19	1900·29	No double here.			2	L.	
New	Cape 32 (C.P.D.–52° No. 6487)	8·4	20·1	52 46	·5	85° ±	3″ ±	1·0	1	I.	Found by Mr. J. A. J. Pead at the transit circle.
New	Innes 364 (C.Z. 13h 1342)	8·7	24·2	68 36	·29	343·5	1·18	2·0	1	I.	A and B. Found with the 18-inch McClean refractor.
	,,	,,	,,	,,	·42	213·3	7 03	2·2	2	I.	A and C. Found with the 18-inch McClean refractor.
42	Innes 298 ...	7·2	25·2	68 43	·43	201·5	0·80	...	2	I.	Both yellow.
43	Russell 220 ...	9·0	25·4	57 55	·56	228·2	0·84	0·3	1	I.	
45	Hargrave 86 ...	7·5	25·8	61 50	·42	239·1	1·84	...	1	L.	
New	Innes 365 ...	6·5	30·4	61 11	·43	233·7	0·3 ±	0·5	2	I.	Pear-shaped. Found with the 18-inch McClean refractor. This is in the Ref. Cat. No. 50 of 13h for *comites* noted at Arequipa. See *Harvard Annals*, vol. xxxii. pt. 2, for description of three companions at 20″, 20″, and 30″, the second being misprinted 2″·0. Correction due to Professor E. C. Pickering.
58	Cape 14	8·5	32·4	41 53	·24	287·8	2·58	...	1	I.	
	,,	,,	,,	,,	·44	285·2	2·94	...	3	L.	
61	*h* 4598	7·0	33·2	74 37	·56	47·1	13·1	3·5	1	I.	
68	Innes 223 ...	6·8	40·2	62 5	·38	320·2	9·05	2·7	1	I.	A very red, B blue.
		,,	,,	,,	·45	319·1	9·39	...	2	L.	
69	M Centauri ...	4·6	40·3	50 56	·56	pr.	30″–40″	...	1	I.	
76	*h* 4616	9·5	44·6	70 41	·56	348·7	4·19	1·0	1	I.	Fixed.

Ref. Cat.	Star.	Mag.	1900. R.A. h m	1900. S D. ° ′	Epoch.	Angle. °	Dist. ″	Diff. of Mags.	No. of Nights.	Obs.	Remarks.
87	Russell 227 ...	6·6	13 49·8	53 39	1900·30	353 8	1·62	2·0	1	I.	Very slow increase in angle and distance.
	,,	,,	,,	,,	·48	354 3	1·75	...	1	L.	
89	Dunlop 151 ...	7·0	50·7	55 33	·50	26·4	14·2	...	2	L.	Rectilinear motion.
90	*h* 4630	8·2	50·9	65 9	·50	313·4	4·18	...	2	L.	Fixed.
91	*h* 4632	6·2	51·1	65 19	·50	14·3	6·47	...	2	L.	A faint *comes* 30″ 50° ±. This would seem to be the more distant of the stars noted by W. H. Pickering.
98	Innes 225 ...	7·2	54·2	62 28	·38	305·4	2·43	3·8	1	I.	Several very faint stars 30″ pr. Many stars within 1′.
2	*θ* Centauri ...	2·2	14 0·8	35 53	·42	No close comp.			1	L.	
13	Harvard (Lac. 5850)	5·2	8·0	56 37	·58	169·5	34·5	5·8	1	I.	An 11^{m}·5 star is more distant S pr.
14	,, (Lac. 5846)	5·9	8·8	66 7	·56	307·2	23·6	6·1	1	I.	
New	Innes 366 (R Centauri)	var.	9·4	59 27	·57	217·6	28·0	12·2 mag.	2	I.	Found with the 18-inch McClean refractor whilst looking for the Harvard companion. The Harvard companion is 355° 30″ 12^{m}. This is identical probably with a small pair 10^{m}·5 and 11^{m}·5 35″ N. pr. R Centauri.
32*a*	C.Z. 14^{h} 602 AB	8·7	11·3	68 10	·56	42·9	52·6	1·5	1	I.	The differences of magnitude recorded would indicate that the catalogue magnitudes are wrong.
,,	C.P.D. −68° 2106 BC	9·0	,,	,,	·56	220·6	8·57	0·5	1	I.	
36	Harvard (Lac. 5934)	6·3	20·8	45 41	·48	143·4	27·0	5·0	1	I.	Another 11^{m}·5 195° ± 30″ ±.
41	,, (Lac. 5950)	5·5	23·7	49 4	·54	18·0	22·3	6·0	2–1	I.	Another *comes* three times as far in opposite direction. These observations do not accord with Arequipa results, viz. 290° 25″ 13^{m}·5.

Ref. Cat.	Star.	Mag.	1900. R.A. h m	S.D. ° ′	Epoch.	Angle. °	Dist. ″	Diff. of Mags.	No. of Nights.	Obs.	Remarks.
54	Harvard (Lac. 5995)	5·3	14 29·8	45 49	1900·48	100 ±	40 ±	6·7	1	I.	
55	Cordoba (36)	8·4	30·1	59 55	·42	144·7	4·02	0·9	2	I.	
New	Innes 367 (C.Z. 14h 1895)	8·0	31·6	64 17	·36	355·3	4·63	3·0	2	I.	Found with the 18-inch McClean refractor.
59	α Centauri ...	0·2	32·8	60 25		Given separately.					
63	α Circini ...	3·4	34·4	64 32	·42	236·8	16·0	...	2	I.	Very slow decrease in angle. See's angle in error?
73	Harvard (Lac. 6039)	5·2	37·4	62 27	·52	64·0	36·5	4·3	2	I.	
New	Innes 368 (C.Z. 14h 2255)	9·2	37·6	62 25	·49	2·9	3·48	1·0	2	I.	Closely N. f. the preceding star. Found with the 18-inch McClean telescope.
77	Innes 235 ...	7·2	39·2	68 6	·49	111·2	0·69	0·7	2	I.	
78	*h* 4696	7·2	39·4	44 27	·51	...	...	...	1	I.	No close comp. A 12m star 50″ ± pr. p.m. small.
80	*m* Hydræ ...	5·1	40·2	25 1	·36	129·7	9·02	...	1	I.	Both stars round.
	,, ...	,,	,,	,,	·48	130·0	8·97	...	1	L.	
81	Harvard (Lac. 6074)	6·5	40·2	51 47	·51	290·6	39·5	5·0	1	I.	A 10·5m star is N. f.
82	,, (Lac. 6059)	6·1	40·3	66 10	·48	Nil	...	...	1	I.	Bris. 5037 = 8m·2 which is in the field has an 11m *comes* 150° ± 30″ ±.
New	Innes 369 (C.Z. 14h 2441)	8·5	40·4	66 10	·49	241·7	2·68	2·3	2	I.	Closely following Lac. 6059. Found with 18-inch McClean telescope. See also preceding entry.
88	Innes 236 ...	5·6	43·2	72 47	·40	103·2	1·59	3·4	2–1	I.	A yellowish, B bluish.
	,, ...	,,	,,	,,	·51	102·3	1·65	...	1	L.	

Ref. Cat.	Star.	Mag.	R.A. 1900. h m	S.D. ° ′	Epoch.	Angle. °	Dist. ″	Diff. of Mags.	No. of Nights.	Obs.	Remarks.
92	*h* 4707	7·7	14 45·8	66 0	1900·50	120·2	0·63	0·1	2	I.	This angle is diminishing and not increasing, as was inferred from *h*'s observations. The change in 65 years is 100° or 460°.
36*a*	Innes 327 ...	8·0	48·6	66 28	·53	77·1	3 10	3·0	2–1	I.	
113	Cape 15	7·1	56·4	71 47	·50	43 2	1·73	...	2	L.	
116	π Lupi	3·8	58·3	46 40	·42	86·4	1·18	...	2	I.	Continued "arrest of motion."
	B.D. −21° 4019	„	58 5	21 42	·4	320 ±	3 ±	0·4	1	I.	Both stars observed in the 2nd Washington Cat.
2	T Triang. Aust. ...	var.	15 0·4	68 20	·63	41·1	41·5	mag. 10 2	1	I.	A $10^{m}\cdot7$ star 311° ± 55″ ±.
9	*h* 4735	7·4	4·8	60 1	·54	33·4	6·92	3·1	2	I.	
11	*h* 4731	9·3	5·2	77 30	·51	249·6	3·12	...	1	L.	
	„	„	„	„	·63	252 0	3·20	0 7	1	I.	Two very faint stars due N.
12	Innes 238 ...	8·2	5·3	44 38	·63	142·6	3·20	2·0	1	I.	A faint star 30″ N. The p.m. is inconsiderable.
39*a*	Innes 329 ...	6·6	5·9	60 58	·63	330·5	0·66	0·6	1	I.	
40*a*	Innes 330 ...	8 0	6·9	74 12	·63	2·1	1 63	1·0	1	I.	
41*a*	Innes 331 ...	8·0	8·7	68 13	·46	5·4	1·53	1·3	2	I.	
17	*h* 4742	6·9	8 8	75 12	·48	200·6	31·9	5·1	1	I.	
	„	„	„	„	·51	200·3	32·0	...	1	L.	
18	δ Circini	5·3	8 9	60 35	·63	315·6	10·4	5·2	1	I.	Identification a little doubtful, is otherwise Lac. 6259.
19	*h* 4750	7·3	9·3	47 40	·63	22·0	13·3	2·7	1	I.	A yellow, B reddish.
New	Innes 370 AB	5·4	10·8	60 8	·60	119·7	5·52	7·6	1	I.	Found with the 18-inch McClean telescope.
24	Harvard AC				·54	244·0	44·6	5·6	2	I.	

Ref. Cat.	Star.	Mag.	1900. R.A. h m	1900. S.D. ° ′	Epoch.	Angle. °	Dist. ″	Diff. of Mags.	No. of Nights.	Obs.	Remarks.
42*a*	Innes 332 ...	6·6	15 11·5	67 7	1900·60	107·9	0·92	2·0	1	I.	
New	Innes 371 (C.P.D. −58°, 5859)	8·9	14·5	58 30	·30	289·4	0·78	0·5	1	I.	Found with 18-inch McClean refractor. Is 11 sec. f. a little S. of Bris. 5272, mag. 8·0.
35	γ Circini ...	4·4	15·4	58 58	·36	79·1	1·12	0·5	1	I.	Smaller components certainly f.
	,,	,,	,,	,,	·41	82·0	...	...	1	L.	
39	Harvard (Lac. 6308)	6·5	16·8	67 57	·48	f.	50″ ±	4·5	1	I.	Harvard star 70° ± 12″ ± 14^m not seen on two nights.
43	Innes 239 ...	7·0	22·6	31 8	·60	2·5	0·29	0·5	1	I.	
44	*h* 4771	8·0	22·6	57 46	·50	188·0	5·30	0·6	2	I.	Fixed.
48	*h* 4777	6·7	24·9	57 4	·50	298·2	5·88	2·0	1	I.	
50	*h* 4773	8·7	25·2	74 1	·42	242·1	6·54	0·2	2	I.	Colours slightly contrasted; pr. star yellowish, f. star bluish. Several small stars near, the closest 12^m·0 is N. pr., and there is a brighter star at double the distance.
55	γ Lupi	3·0	28·5	40 50	·54	90·0	0·34	0·2	3–2	I.	Smaller star follows. In contact. Nature of orbit still in doubt.
56	*d* Lupi	4·8	29·0	44 37	·46	358·8	2·42	...	2	I.	Prof. See's angle seems to require −10°.
60	Innes 242 ...	7·5	31·2	31 12	·61	47·4	1·72	0·1	1	I.	
62	ω Lupi	4·0	31·3	42 14	·56	25·8	11·6	7·2	2	I.	Chief star orange red. Common p.m. almost certain.
72	Bris. 5413 AB (Dunlop 190)	8·3	35·0	57 48	·47	93·2	5·68	2·0	1	I.	A red, B blue.
		,,	,,	,,	·49	94·1	5·73	...	2	L.	
New	Bris. 5413 AC (Innes 372)	,,	,,	,,	·48	50·0	33·8	3·2	1	I.	Found with the 18-in. McClean telescope.
		,,	,,	,,	·49	48·7	33·9	...	2	L.	

Ref. Cat.	Star.	Mag.	R.A. 1900. h m	S.D. ° ′	Epoch.	Angle. °	Dist. ″	Diff. of Mags.	No. of Nights.	Obs.	Remarks.
74	*h* 4795	7·4	15 36·9	58 48	1900·50	222·0	7·70	...	2	I.	Fixed. An 11^m·0 star 137° ±, 20″ ±.
80	Rumker 20 ...	5·8	38·8	65 8	·50	153·1	2·15	0·3	2	I.	A 12^m star N. f. 40″ ±. This would seem to be the nearer of the two stars noted at Arequipa.
82	Innes 245 ...	7·5	40·0	43 56	·61	328·0	0·91	1·0	1	I.	
44*a*	„ 333 ...	6·7	46·0	77 44	·48	133·7	0·84	0·1	1	I.	
93	Dunlop 195 AB	6·8	47·5	50 2	·37	10·8	12·0	0·5	1	I.	Colours slightly contrasted; A bluish, B yellowish. Fixed.
	„ „	„	„	„	·62	9·6	12·0	...	1	L.	
	„ AC	„	„	„	·37	289·3	28·9	...	1	I.	
	„ „	„	„	„	·62	289·9	...	...	1	L.	
101	η Lupi	3·8	53·5	38 7	·69	19·3	14·7	...	1	I.	The lesser star is orange red.
New	Innes 373 (Lac. 6655).	7·0	58·0	39 10	·69	217·8	8·74	4·0	1	I.	Found with the 18-inch McClean telescope. Also contained in a M.S. of new pairs received on October 20 from Professor E. C. Pickering. C.Z. xv. 3981, mag. 7·8 red, is 13′ N. f.
2	*h* 4831	6·5	16 0·7	36 29	·68	358·5	40 7	5·5	1	I.	In Ref. Cat. substitute *h* 4831 for Harvard.
4	β 949	6·5	3·0	9 50	·42	Not seen double			1	L.	
15	δ Triang. Austr. ...	4·0	6·3	63 26	·41	No comp. seen			1	I.	At Arequipa in 1891 Professor W. H. Pickering records a distant *comes*. The Cape observations refer to the close companion found by Mr. H. C. Russell at Sydney.
	„ ...	...	...	...	·50	„			1	L.	
17	θ Normæ	5·3	8·0	47 7	·50	Nil.	...	...	1	L.	
					·68	Nil.	Moon	...	1	I.	
48*a*	Innes 335 ...	8·5	8·8	71 12	·46	204·6	3·72	2·0	2	I.	Some faint stars 50″ away.

Ref. Cat.	Star.		Mag.	1900. R.A. h m	S.D. ° ′	Epoch.	Angle. °	Dist. ″	Diff. of Mags.	No. of Nights.	Obs.	Remarks.
18	Harvard(Lac. 6735)		5·4	16 8·9	53 34	1900·68	...	...	...	1	I.	Two stars seen as in Ref. Cat. No star 29c°. Many faint stars around, one 13^{m}·5 at about 240°.
24	γ_2 Normæ	...	4·2	12·4	49 55	·68	0·9	41·9	5·5	2	I.	A deep yellow. Change probably due to the p.m. of A.
46	*h* 4854 ...	...	6·6	21·4	57 32	·41	Single	...	...	1	I.	Not a good night.
49*a*	Innes 336	...	7·4	22·9	62 4	·55	195·5	1·17	0·2	2	I.	
New	Innes 374 (Lac. 6874)	AB	8·0	28·4	51 2	·71	300·3	2·60	3·0	1	I.	Found with the 7-inch refractor.
		AC	„	„	„	·71	357·7	23·0	5·0	1	I.	Found with the 18-inch McClean telescope.
53	β Apodis ...	...	4·2	28·8	77 19	·46	72·3	51·3	...	2	I.	The known p.m. of β Apodis nearly accounts for the change shown since *h*.
61	Lac. 6912	AD	5·6	33·9	48 34	·69	162·0	13·1	4·4	1	I.	AB is Melbourne [8]. AC = *h* 4876. D, E, and F agree nearly enough with the Arequipa estimates. E was seen by *h* and is unchanged.
	„	AE	...	...	...	·60	14·8	13·5	5·4	2	I.	
	„	AF	...	...	...	·69	194·5	21·2	6·4	1	I.	
63	*h* 4874	AB	7·5	34·1	60 44	·37	296·9	3·40	0·0	1	I.	Colours slightly contrasted, f star yellowish. A 12^{m} star 10″ N. pr.
	„	„	...	...	...	·50	298·7	3·24	...	1	L.	
	„	BC	...	...	...	·50	325·2	14·9	...	1	L.	
65	Innes 39 ...	...	8·0	35·3	32 38	·69	...	...	...	1	I.	The only companion is a long way S.f.
67	Harvard (Lac. 6906)	AB	5·3	36·6	66 55	·41	104 ±	20 ±	6·7	1	I.	CB might be called a wide double near a bright star. Arequipa star 180° 30″ not seen.
		AC	„	„	„	·41	123 ±	25 ±	6·2	1	I.	
68	Harvard(Lac. 6927)		6·6	36·8	52 58	·51	N.f.	40 ±	5·4	1	I.	
69	„ (Lac. 6946)		6·4	37·0	37 58	·51	160 ±	50 ±	5·6	1	I.	
50*a*	*h* 4865 ...	...	8·9	41·1	83 50	·51	312·9	4·30	...	1	I.	

Ref. Cat.	Star.	Mag.	1900. R.A. h m	1900. S.D. ° ′	Epoch.	Angle. °	Dist. ″	Diff. of Mags.	No. of Nights.	Obs.	Remarks.
72	Innes 99	7·5	16 42·4	43 46	1900·69	75·2	1·12	0·3	1	I.	
New	Innes 375 (C.P.D. −40°, No. 7567)	9·8	46·8	40 54	·69	161·5	4·06	2·5	1	I.	Found with the 18-inch McClean refractor. Is 65 secs. pr. next star.
81	Innes 101 ...	9·0	47·9	40 54	·69	352·5	2·70	1·2	1	I.	
92	Harvard (Lac. 7052)	6·5	52·0	54 27	·68	71·2	20·2	6·0	1	I.	Difficult.
99	ϵ_2 Aræ	5·4	55·2	53 5	·68	Nil	Moon	...	1	I.	
103	*h* 4909	8·1	56·2	50 56	·37	158·8	11·3	...	1	I.	
106	*k* Scorpii	5·0	58·3	33 59	·51	Nil	...	...	1	I.	
108	Lac. 7123 AC	6·5	59·6	37 5	·68	187·2	43·5	6·5	1	I.	This is the Arequipa star. The close star = 10·5 mag. was seen here, but the first observation is due to Professor See. It is contained in a recent MS. list of stars since found at Arequipa.
5	Dunlop 214 ...	6·5	17 3·1	67 4	·39	350·7	28·7	...	2	I.	*Comes* double 95° ?
8	*h* 4920	6·9	4·3	58 28	·63	328·6	2·91	...	1	L.	
16	Lac. 7171 AB, C	7·0	7·5	39 39	·63	335·6	14·4	...	1	L.	*h* 4926. No mention made of the close pair λ 321.
	„ AB, D	...	...	...	·63	210·2	17·0	...	1	L.	
20	Innes 104 ...	6·5	9·1	69 56	·72	140·4	1·66	2·5	1	I.	
31	Brisbane ... (Lac. 7194) AB	5·5	11·4	46 32	·62	66·5	2·32	...	1	L.	Distance decreasing. Period probably under 60 years. p.m. = 0″·93 towards 77°·6.
	„ „	„	„	„	·63	69·6	2·13	...	8	I.	
	„ „	„	„	„	·71	69 7	2·36	...	1	G.J.	
	„ „ AC	„	„	„	·71	279·0	42·0	6·6	2	I.	
	„ „ AD	„	„	„	·71	30 ±	47 ±	8·4	1	I.	

Ref. Cat.	Star.		Mag.	R.A. 1900. h m	S.D. ° ′	Epoch.	Angle. °	Dist. ″	Diff. of Mags.	No. of Nights.	Obs.	Remarks.
33	*h* 4931		7·5	17 11·8	59 20	1900·66	257·4	1·26	0·2	2	I.	Fixed.
35	Lac. 7215...	AB	5 9	12·1	34 53	·53	299·0	2·17	...	4	L.	(β 416)
	„ ...	AC	„	„	„	·53	130·9	30·0	...	4 3	L.	*h* 4935.
39	Harvard (Lac. 7213) ...		6·4	14·3	57 55	·66	187·4	2 11	4 6	2	I.	Fine pair. A yellowish. Also 13^m star 270° distant; 11^m S. f. more distant, and other faint stars about. The 11^m was also noted at Arequipa.
42	ι Aræ		5·4	15·8	47 22	·67	62·0	43·0	5·3	1	I.	Noted in looking for the Arequipa star (335°, 15″ 9^m·0 W.H.P.)
New	Innes 385 (Bris. 6042) ...		7·5	16·0	59 7	·72	184·3	0·51	0·3	1	I.	Found with the 18-in. McClean refractor. Both yellow. A 13th mag. star 212°·6, 18″·6, and a 14th mag. star 113° ±, 35″ ±.
48	κ Aræ ...	AB	5·3	18·2	50 33	·67	159·4	76·4	4·4	1	I.	Arequipa stars not seen.
New	... ...	BC	„	„	„	·67	274·7	4·71	1·0	1	I.	
53	Harvard (Lac. 7265) ...		6·3	20·0	52 13	·67	...	...	...	1	I.	Many faint stars about; none within 30″–40″.
54	Harvard (Lac. 7263) ...		6·0	20·4	55 5	·67	151·1	37·2	5·5	1	I.	AC. B evidently not seen.
New	Cape 29 (C.P.D. – 42° 7799) ...		8·9	23·5	42 59	·67	339·7	4·90	0·8	1	I.	Found by Mr. W. H. Cox at the transit circle. Mag. from Cord. D. is 0·5 too faint. A similar but fainter pair N. pr.
New	Innes 376 (C.P.D.–65° 3457) ...		9 0	23·9	65 57	·7	40 ±	1 ±	0·4	1	I.	Found with the 7-in. Closely S. pr. Bris. 6087, mag. 8·5.
64	Innes 40		6·5	24·4	45 58	·63	210·6	17·8	4·0	2	I.	B bluish. The p.m. is very small.

Ref. Cat.	Star.	Mag.	1900. R.A. h m	S.D. ° ′	Epoch.	Angle. °	Dist. ″	Diff. of Mags.	No. of Nights.	Obs.	Remarks
74	Innes 106 ...	7·7	17 29·6	49 11	1900·66	39·0	0·86	0·8	2	I.	
New	Innes 377 ... (U.A. 1 Pavonis)	7·0	34·7	57 40	·72	327·3	15·1	7·0	1	I.	A red 8 remarkable, is 8·8 in C.P.D. Found with McClean telescope.
89	Innes 248 ...	8·0	38·2	46 53	·69	127·8	1·78	1·3	2	I.	A 13^m star $13° \pm 30''$.
	ι_1 Scorpii ...	3·1	40·6	40 5	·63	96·3	37·0	8·7	2	I.	Weighted mean.
91	Innes 108 ...	9·3	41·0	40 6	·57	256·1	4·91	1·0	2	I.	
6	ι_2 Scorpii	4·9	43·2	40 4	·58	36·8	32·9	6·1	2	I.	
98	Harvard (P. 17^h 236) ...	6·5	44·5	40 45	·69	194·2	27·8	5·5	2	I.	A orange yellow 4. Many faint stars at a little greater distance.
105	h 4992	8·0	48·9	57 39	·69	13·9	4·28	0·6	2	I.	B yellowish. Change.
108	Innes 109 ...	9·3	49·4	28 4	·54	242·5	5·63	2·0	1	I.	
109	Cordoba (50) ...	7·3	49·9	39 55	·71	126·5	3·45	1·7	1	I.	A orange yellow, B intense blue ; very remarkable.
116	Innes 230 ...	8·6	53·7	37 42	·62	140·3	7·88	1·5	2	I.	
125	Harvard (Lac. 7542) ...	6·4	58·1	35 54	·54	289·7	12·6	5·1	1	I.	
129	h 5014	5·2	59·6	43 26	·63	240·7	1·62	...	1	L.	
2	Harvard (Lac. 7540) ...	6·5	18 1·1	59 3	·42	S.pr.	$40'' \pm$	5·5	1	I.	And more distant stars. (For S. pr. to read N. pr. to agree with Arequipa ?)
5	h 5021 (Lac. 7566)	7·7	3·6	56 26	·50	326·5	5·26	3·8	2–1	I.	No certain change. Wrongly identified by h, so that the note in Ref. Cat. requires alteration.
6	β 245	5·6	3·7	30 45	·66	353·3	3·92	...	2	L.	Fixed.
7	h 5023	8·0	3·8	40 27	·62	276·8	9·18	...	2–1	L.	
17	h 5032	7·2	6·6	43 14	·54	Nil	...	...	2	I.	Neighbouring stars also examined.

Ref. Cat.	Star.	Mag.	1900. R.A. h m	1900. S.D. ° ′	Epoch.	Angle. °	Dist. ″	Diff. of Mags.	No. of Nights.	Obs.	Remarks.
19	Innes 111 ...	7·2	18 7·6	56 41	1900·60	305·4	0·84	2·5	2–1	I.	Observations discordant (310°·6, 300°·3).
28	Innes 249 ...	6·4	10·0	63 55	·60	4·3	7·10	4·6	2	I.	
54	Harvard (Lac. 7696) ...	5·8	21·3	57 35	·52	120·2	34·6	4·7	3–2	I.	A fainter and more distant comp. pr.
69	Innes 250 ...	7·5	34·1	42 16	·55	132·8	0·95	0·7	2	I.	
72	λ Coronæ Austr.	5·2	36·9	38 25	·55	215·0	29·3	3·8	2	I.	A fainter, more distant star 56° ± .
	AB	„	,,	,,	·56	214·8	29·2	...	1	L.	
	„ AC	„	„	„	·56	57·2	40·2	...	1	L.	
	Hargrave (C.Z. 18h 2002) ...	8·6	36·7	54 .0	·60	131·3	3·74	0·1	2	I.	Measured by Hargrave as *h* 5057 in error. See next star.
74	*h* 5057	9·2	37·4	54 2	·60	79·9	12·1	1 0	2	I.	Three faint stars near, one of which is mentioned by *h*.
86	*h* 5066	6·7	44·0	41 11	·65	87·2	9·91	...	2	I.	No certain change. Colours slightly contrasted. A yellowish.
89	Innes 112 ...	6·7	46·6	47 24	·56	182·7	1·72	...	1	L.	The p.m. is very small.
	„ ...	„	„	„	·58	181·4	1·54	2·8	2	I.	
96	Innes 113 ...	6·9	51·3	48 38	·55	230·4	3 07	4·1	2	I.	
100	Innes 252 ...	7·7	54·9	34 38	·61	5·9	0·97	0·3	2	I.	Prof. See misidentified this pair, and registered it as λ 367. Ref. Cat. 18h, No. 109, should be struck out.
101	Cordoba (53) ...	7·5	55·1	40 48	·60	Single	...	...	1	I.	The companion was observed on one night at Cordoba, on which occasion the chief star was not observed.

Ref. Cat.	Star.	Mag.	1900. R.A. h m	1900. S.D. ° ′	Epoch.	Angle. °	Dist. ″	Diff. of Mags.	No. of Nights.	Obs.	Remarks.
105	Harvard (Lac. 7949) ...	6·0	18 56·2	51 9	1900·48	77·3	21·7	5·7	2	I.	No other star seen.
107	ζ Sagittarii ...	2·7	56 3	30 1	·83	71 6	0·44	...	5	I.	Day observations. Weighted mean.
New	Cape 30 (C.P.D.–42°,8577) ...	8·7	56·3	42 47	·68	77·9	4·11	0·0	2	I.	Colours very slightly contrasted, pr. star yellowish. Found by Mr. J. A. J. Pead at the transit circle.
113	γ Coronæ Austr.	4·3	59·6	37 12	·62	142·7	1·94	0·0	2	I.	
	„	„	„	„	·65	142·4	1·81	...	2	L.	Professor's See's angle seems to require +10°.
7	Harvard 152 ...	8·2	19 8·1	29 26	·82	260·8	1·07	1·0	1	I.	
8	Cordoba (55) ...	8·5	8·4	27 29	·70	329·1	2·21	...	1	L.	
9	Innes 114 ...	7·8	10·5	63 4	·64	285·0	0·53	0·5	2	I.	
13	β_1 Sagittarii ...	4·1	15·5	44 39	·65	77·9	27·9	...	2	I.	B deep yellow. Doubtful if all the change is due to the p.m. of the chief star.
14	*h* 5103	8·8	15·5	71 58	·51	244·2	13·3	2·7	1	I.	
	„	„	„	„	·61	243·7	12 6	...	1	L.	
16	Innes 115 ...	8·0	16·6	62 22	·56	54·7	2·83	2·9	2	I.	
	„	„	„	„	·61	56·0	2·97	...	1	L.	
17	Innes 116 ...	8·4	16·7	46 8	·55	30 2	2·31	1·0	2	I.	An orange-coloured star 17″ S. 8·6ᵐ.
24	*h* 5114	5·4	19·8	54 31	·72	No comp. seen			1	I.	A golden yellow. C.Z. 19ʰ 774 which is pr.; has a 13ᵐ *comes* 200° ± 10″ ±.
30	Innes 254 ...	8·0	23·1	48 38	·54	212·8	0·93	0·0	2	I.	
32	„ 117 ...	6·9	23·4	60 29	·64	184·1	0·86	0·6	2	I.	
34	„ 118 ...	7·0	25·5	46 59	·54	127·5	1·06	2·0	2	I.	A yellow, B bluish. Common p.m. of 0″·17 towards 159°·0.
35	„ 255 ...	8 6	25·7	48 55	·54	173·2	2·49	2·6	2	I.	

Ref. Cat.	Star.		Mag.	1900. R.A. h m	S.D. °	Epoch.	Angle.	Dist.	Diff. of Mags.	No. of Nights.	Obs.	Remarks.
47	H. I. 13	AB	7·1	19 33·2	10 23	1900·70	321·6	3·54	...	1	L.	
	,,	AC	,,	,,	,,	·70		Invisible			L.	Clear night, dark field.
	,,	AD	,,	,,	,,	·70	167·6	27·5	2·9	1	L.	
49	Innes 119	...	7·5	34·0	59 14	·61	180·6	1·27	...	1	L.	
	,,		,,	,,	,,	·65	179·3	1·18	0·9	2	I.	Both yellowish.
51	Cordoba (56)	...	7·0	34·5	53 11	·51	52·5	3·17	1·5	2	I.	
	,,		,,	,,	,,	·61	52·8	3·16	...	1	L.	
54	Lac. 8194	AB	7·0	40·2	62 3	·64	152·1	0·52	0·5	2	I.	Both yellowish. Innes 120.
	,,	AB, C	,,	,,	,,	·64	344·0	14·1	3·5	2	I.	No change in the wide pair. *h* 5141.
61	Innes 121	...	5·5	42·3	59 27	·64	89·0	0·63	2·5	2–1	I.	
62	,, 122	...	7·6	43·8	42 7	·61	340·3	5·17	...	1	L.	
			,,	,,	,,	·62	338·4	5·04	2·5	2	I.	
64	Dunlop 227	...	5·3	44·7	55 13	·68	149·5	23·4	...	2	I.	A deep yellow. B blue, fine contrast. Fixed. A $12^m·5$ star is $19'' \pm$ N. pr.
66	*h* 5152 ...	...	8 1	47·2	30 31	·70	154·8	6·01	...	1	L.	
73	Innes 256	...	6·9	54·2	47 40	·70	201·4	0·99	2 0	2	I.	The p.m. is insensible.
7	*h* 5167 ...	...	7·3	20 2 9	63 55	·65	35·5	7 61	...	2–1	I.	No change.
8	Innes 123	...	7·1	3·5	47 2	·66	174·8	10·8	3·9	3	I.	A yellow, B blue. The p.m. is very small.
9	*h* 5173 ...	...	5·4	4·6	36 21	·66	122·0	9·09	...	2	L.	An important system of the 61 Cygni or P. XIV. 212 class.
12	*h* 5177 ...	...	8·1	6·9	57 16	·65	28 5	8·11	...	2	I.	No change.
13	*h* 5178 ...	...	6 9	7·3	34 25	·60	10·0	2·79	...	2	L.	

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Ref. Cat.	Star.		Mag.	1900. R.A. h m	1900. S.D. ° ′	Epoch.	Angle. °	Dist. ″	Diff. of Mags.	No. of Nights.	Obs.	Remarks.
14	Innes 299	...	8·5	20 7·3	36 20	1900·75	39·0	0·54	0·3	2	I.	
17	„ 124	...	7·7	9·5	63 28	·71	Nil	...	...	3	I.	
18	„ 125	...	8·2	9·5	46 13	·70	42·2	1·46	0·7	2	I.	Slightly contrasted in colour, A yellowish. The p.m. is very small.
19	O. Stone (Lac. 8392)		7·3	10·6	32 55	·60	304·2	2·36	...	1	L.	
New	Innes 378 (C.Z. 20h 287)		8·5	10·6	46 16	·70	148·7	3·94	3·5	2	I.	Found with the 18-in. McClean telescope.
28	Innes 126	...	9·0	15·3	57 26	·70	77·0	1·64	0·2	2	I.	
30	κ_1 Sagittarii	AB	5·7	15·6	42 22	·66	306·9	29·9	6·8	2	I.	The p.m. of the chief star almost accounts for the change since *h*. A more distant star S.
		AC	„	„	„	·66	277·0	50·7	5·8	2	I.	
48	Innes 127	...	9·0	27·1	44 51	·51	54·4	...	...	1	I.	1900·66. No sign of duplicity. I. 1900·82, single, medium definition, I. Still, there can be but little doubt that this is a double star, as it was picked up independently on *three* nights with the 7-in. There is a faint star between this and ν Microscopii.
53	α Indi	AB	3·2	30·5	47 38	·74	199·8	66·5	...	1	L.	
		AC	„	„	„	·74	344·5	63·0	10·8	1	L.	
61	Innes 128	...	8·0	36·3	52 9	·58	326·6	3·04	2·5	2	I.	
72	Rumker 26	...	5·8	43·3	62 48	·56	95·0	2·63	...	1	L.	
	„		„	„	„	·60	95·2	2·68	0·3	2	I.	

Ref. Cat.	Star.	Mag.	1900. R.A. h m	1900. S.D. ° ′	Epoch.	Angle. °	Dist. ″	Diff. of Mags.	No. of Nights.	Obs.	Remarks.
57*a*	Innes 337 ...	8·9	20 45·4	87 27	1900·85	289·2	1·01	0·7	**2**	I.	In addition to the *comes h* 5192, there is an 11^{m}·0 star 50″ S.f.
81	„ 18 ...	7·4	47·9	52 30	·58	3·7	4·36	3·2	2	I.	
83	„ 129 ...	7·7	48·6	59 39	·68	17·5	1·65	2·0	2	I.	A 13^{m} star 30° ± 30″ ±.
95	„ 130 ...	7·0	57·3	48 21	·57	316·8	3·22	3·5	2	I.	
96	*h* 5233	7·6	57·5	83 40	·60	269·3	11·7	3·9	2	I.	
New	Innes 379 AB (Lac. 8625)	5·9	58·8	73 34	·82	138 ±	...	...	1	I.	Found and estimated with the 18-in. McClean telescope.
100	Harvard AB, C (Lac. 8625)	„	„	„	·82	135·6	7·67	7·1	1	I.	AB is very close, the direction of B is towards C. AB = yellow 4.
1	Innes 301 ...	9·0	21 0·6	36 55	·58	339·9	3·98	0·5	2	I.	
8	Innes 258 ...	7·7	4·8	60 27	·72	102·7	0·59	0·4	2	I.	
15	θ Indi	4·6	12·7	53 52	·58	285·1	4·42	...	2	L.	
19	Innes 131 ...	9·0	14·8	52 12	·73	Nil	...	...	1	I.	
20	Innes 132 ...	7·5	16·1	53 22	·72	297·9	1·40	1 6	2	I.	
22	θ_2 Microscopii ...	5·9	18·0	41 26	·76	292·3	0·95	0·3	2	I.	Probably fixed, but the angles are very discordant, ranging over 41° !
27	*h* 5267	7·2	20·0	46 30	·71	Nil	...	...	1	I.	A 13^{m} star 200° ± 25″ ±. The chief star has a p.m. of about 0″·13 towards 10°, but this hardly accounts for the disappearance of the *h* companion.
28	Melbourne (6) ...	5·6	20·6	42 59	·58	145·8	2·88	...	2	L.	
New	Innes 380 (Lal. 41984)	8 2	30·0	19 13	·84	356·0	1·34	0·8	1	I.	A white, B slightly yellowish. Found with the 7-in. With the 18-in. McClean telescope a 12^{m}·5 star is seen at 71° ± 42″ ±.

Ref. Cat.	Star.	Mag.	1906. R.A. h m	1906. S.D. ° ′	Epoch.	Angle. °	Dist. ″	Diff. of Mags.	No. of Nights.	Obs.	Remarks
41	Innes 302 ...	9·0	21 32·8	11 21	1900·84	89·4	2·48	1·2	1	I.	
45	λ Octantis ...	5·4	35·6	83 11	·49	77·7	3·35	2·5	1	I.	A yellow, B bluish.
	„ ...	„	„	„	·58	80·5	3·10	...	2	L.	The change is very slow.
53	Innes 19	7·0	40·9	65 58	·63	341·9	1·35	...	2	L.	
55	Brisbane (Lac. 8912)	5·7	41·8	47 45	·60	359·4	46·3	...	1	L.	
56	θ Piscis Australis	5·2	41·9	31 22	·86	339·0	35·9	5·3	2	I.	Common p.m. of 0″·65.
61	Cordoba (59) ...	9·2	43·5	54 52	·86	151·2	3·71	0·5	2	I.	Colours slightly contrasted.
58*a*	Innes 338 ...	8·0	54·1	56 57	·83	279·3	0·88	1·4	2	I.	Angle = mean of 285°·2 and 273°·4.
New	Innes 381 (C.Z. 21^h 1813)	8·2	59·2	56 57	·86	112·5	1·85	1·8	2	I.	Colours slightly contrasted. A yellowish. Found with the 18-in. McClean telescope.
59*a*	Innes 339 ...	8·5	22 5·8	75 29	·78	179·8	2·42	1·2	2–1	I.	
14	Innes 20	6·8	11·0	63 19	·79	343·2	0·68	0·5	2	I.	
15	Harvard (Lac. 9076)	5·4	11·7	54 6	·86	16·3	2·30	5·1	2	I.	
16	Innes 303 AB	8 2	12·3	50 24	·75	33·0	25·4	...	2	I.	
	„ BC	„	„	„	·75	56·8	2·72	0·3	2	I.	
17	Innes 134 ...	7 7	16·1	56 39	·82	307·5	0·58	0·3	2	I.	
18	π_1 Gruis	6·7	16·6	46 27	·75	201·6	3·05	5·0	2	I.	The p.m. is small and uncertain.
	„	„	„	„	·76	201·1	2·71	...	2–1	L.	
New	Innes 382 (π_2 Gruis)	5 8	17·0	46 26	·84	207 9	4 72	6 7	1	I.	Found with the 18-in. McClean refractor. The p.m. of the large star is 0″·22 towards 108°·7.

Ref. Cat.	Star.	Mag.	1900. R.A. h m	1900. S.D. ° ′	Epoch.	Angle. °	Dist. ″	Diff. of Mags.	No. of Nights.	Obs.	Remarks.
New	Innes 383 (Lac. 9112)	5·4	22 18·3	58 18	1900·84	247 ±	41 ±	9·1	1	I.	Found with the 18-in. McClean refractor, but too faint to measure. Retained on account of the p.m. of the chief star, which is 0″·384 towards 155°·8.
20	Innes 136 ...	7·5	19·9	45 37	·75	269·4	1·78	1·0	2	I.	Colours slightly contrasted, A yellowish, B bluish.
22	Innes 137 ...	6·9	20·8	58 31	·71	Not seen double			1	L.	
	,,	,,	,,	,,	·84	333·9	1·94	3·0	1	I.	
24	ζ Aquarii ...	3·8	23·7	0 32	·82	323·3	3·20	...	1	L.	
30	β Piscis Australis	4·5	25·8	32 51	·66	172·4	30·5	...	2	L.	
37	Innes 138 ...	6·6	32·0	40 23	·66	280·6	3·17	4·4	1	I.	
	,,	,,	,,	,,	·71	278·9	3·46	5·3	1	L.	
38	*h* 5348	8·5	32·7	59 20	·71	274·8	4·20	3·4	1	L.	The only complete measure.
39	H IV. 117 ...	7·5	34·2	28 52	·85	60·1	3·16	...	1	L.	Fixed.
40	Lalande 180 ...	8·0	34·3	13 8	·85	314·5	4·01	...	1	L.	
48	Innes 304 ...	8·0	40·9	48 51	·61	358·3	4·49	0·2	1	I.	Colours slightly contrasted, A yellow.
	,,	,,	,,	,,	·78	359·9	4·46	...	2	L.	
49	Innes 140 ...	8·3	41·6	55 1	·61	271·3	4·24	1·5	1	I.	
	,,	,,	,,	,,	·85	269·1	4·46	...	1	L.	
New	Harvard (P. XXII. 224)	6·6	44·4	33 20	·87	90 ±	Doubtful		1	I.	Perhaps elongated, independent setting. Mr. Clymer at Arequipa gives 90° ± 0″·4 ± doubtful. Communicated by Professor E. C. Pickering.
New	Cape 31 (C.P.D. – 58°8008)	8·2	45·2	58 5	·87	172·9	7·85	0·5	1	I.	Found by Mr. Cox at the transit circle.

Ref. Cat.	Star.	Mag.	1900. R.A. h m	S.D. ° ′	Epoch.	Angle. °	Dist. ″	Diff. of Mags.	No. of Nights.	Obs.	Remarks.
60*a*	Innes 340 ...	6·0	22 45·7	63 43	1900·80	20·0	1·22	3·0	2	I.	A yellow, B bluish.
55	γ Piscis Australis	4·6	47·0	33 24	·77	267·9	4·08	...	1	L.	
57	Innes 22	6·8	49·5	49 0	·80	184·7	0·45	0·2	2	I.	Both yellow.
67	Innes 259 ...	7·5	58·3	55 34	·79	97·4	1·03	0·2	3	I.	
9	*h* 5387	7·7	23 8·0	41 29	·85	277·4	7·84	...	1	L.	
13	Innes 143 ...	7·2	9·6	60 14	·79	9·8	2·92	3·5	3	I.	A yellow 5, B bluish.
20	*h* 5392	8·5	12·7	58 51	·72	331·3	20·9	...	1	I.	The change in this pair would be accounted for by a p.m. of 0″·23 towards 137° in the chief star. Its p.m. from meridian observations is doubtful in α and = −0″·20 in δ.
	,,	,,	,,	,,	·81	331·2	20·9	...	2	L.	
31	Innes 144 ...	8·2	20·2	43 27	·74	180·3	0·80	0·4	2	I.	
37	Innes 23	7·0	22·6	56 59	·74	321·8	0·84	0·9	2	I.	Both white.
38	Innes 145 ...	8·7	25·3	58 40	·74	109·2	1·65	0·3	2	I.	
56	Cordoba (67) AB	9·0	39·5	45 48	·87	307·3	4·03	...	1	L.	
	,, BC	,,	,,	,,	·87	19·0	23·1	...	1	L.	
61*a*	Cape 25	8·2	41·5	45 37	·64	167·4	2·49	0·2	2	I.	
60	Cordoba (68) ...	8·1	42·2	61 4	·67	101·0	5·94	1·0	1	I.	
	,, ...	,,	,,	,,	·78	100·8	5·60	...	2	L.	
61	Innes 305 ...	6·9	42·8	51 27	·78	123·1	3·45	5·1	2	I.	A yellowish, B bluish.
	h 5428 (Bris. 7341)	6·7	48·4	66 30	·90	114·8	12·3	5·3	1	I.	No change since *h*. Common p.m. of 0″·12 towards 336°·5.
66	Innes 146 ...	7·3	23 49·9	37 55	·84	221·9	0·74	0·7	1	I.	
	,, ...	,,	,,	,,	1900·85	217·2	0·82	...	1	L.	

Results for α Centauri.

Considerable attention was paid to *α Centauri*, because the star is passing through its greatest apparent distance. We have the following ephemerides :—

Date.	Roberts (A.N. 3313).		Doberck (A.N. 3330).		See (*Monthly Notices*, liv.)	
	°	″	°	″	°	″
1899·5	209·5	21·90	209·9	21·76	209·5	21·92
1900·5	209·9	21·94	210·4	21·79	210·0	21·96
1901·5	210·4	21·94	210·8	21·73	210·4	21·95

The screw value of the Repsold micrometer rests on seven sets of measures of the difference of declination between ζ_1 and ζ_2 *Reticuli*, made on 1899 December 2, 3, and 4.

The distance between these two stars was determined with the 7-inch heliometer, viz.—

	Distance.	Position Angle.
	″	° ′
1900·0	309·99	35 44

Rev.
Resulting value of 1 = 17″·685.

On 1900 September 1 Mr. J. Lunt took some differences of declination of *Bradley* 2188 and *θ Ophiuchi*, which gave 17″·664 ; but as the difference of declination between these two stars has not been accurately determined this value has only been taken as showing that the adopted value is almost certainly correct within a $\frac{1}{300}$th part.

The periodic errors of the screw at their maximum amount to 0″·03. In repeated measures such as of *α Centauri* these are eliminated by altering the zero of the fixed wire, which has been done frequently.

The progressive errors are given in the following table :—

Rev.	Correction to be applied to the Reading.	Rev.	Correction to be applied to the Reading.
0	+0·0086	14	−0·0002
2	57	16	7
4	36	18	18
6	19	20	33
8	7	22	56
10	+0·0002	24	−0·0084
12	0·0000		

These rest on measures made by Mr. S. S. Hough and Mr. R. T. A. Innes on 1899 December 7, 8, 11, and 13.

Over the part of the screw used in the micrometer measures

these corrections are almost insensible. In the case of *α Centauri* the correction amounts to $-0''\cdot005$, or so nearly equal to the correction for refraction that in this case the one has been taken as cancelling the other, viz. —

Hour Angle.	Correction for refraction to distance $21''\cdot5$ of *α Centauri*.
h	″
−4	+0·006
−2	·005
−0	·006
+2	·007
+4	+0·007

The measures are :—

Date.	P.A.	Distance.	Observer.	No.	Telescope.
	°	″			
1900·07	210·5	21·71	L.	7 days	E.
·07	210·5	·77	I.	4–5 „	„
·45	209·9	·96	„	5 nights	W.
·50	210·4	·84	L.	7 „	„
·64	210·7	·73	„	3 „	„
·66	210·2	·76	I.	7 days	„
·82	210·3	·81	„	2 „	E.

These measures are weighted according to the number of settings, the average number being five in angle and five double distances on each occasion.

It will be seen that the mean place, which is about $210°\cdot4$, $21''\cdot79$, agrees exactly with Dr. Doberck's ephemeris.

No temperature correction has been applied—the range was from 52° F. to 81° F.=29°, and the amount could hardly be so great as $0''\cdot02$ on $22''$. It is hoped to obtain a good series of measures in 1901.

Besides the measures of the large star, some observations were also made of the faint stars in the same field.

Stars.	Date.	P.A.	Dist.	Observer.		
		°	″			
B−C	1900·48	236·9	32·7	I.	1n	Very poor measures, star C invisible when bright star in field.
A−D	·33	265·0	70·3	L.	1n	
„	·37	264·3	69·4	I	1n	
A−E	·48	43·0	72·5	L.	4–3n	
A−F	1900·42	350·9	>73″	L.	1n	

In 1891 a careful examination of *α Centauri* was made at Arequipa (see *Harvard Annals*, vol. xxxii. pt. ii. p. 307), and the following positions obtained by estimation :—

Star.	Mag.	P.A.	Dist.
		°	″
c	12·0	5	50
d	12·5	257	60
e	11·0	180	70
f	11·0	330	100
g	9·0	290	110

To connect these with the Cape stars the following diagram has been made in which the change due to the great proper motion of *α Centauri* is shown :—

A study of the diagram shows the following identities :—

Arequipa.	Cape.
c	E
d	C
e	—
f	F
g	D

It is already evident that none of the stars E, C, F, and D belong to the system of *α Centauri*. D, which is evidently equal to the Arequipa *g*, has also been measured at Sydney, viz.—

1896·5	267°·2	82″·5	Sellors	3n

and the change between this and the Cape measures is due to the proper motion of *α Centauri* (3″·688 towards 281°·5). The star *e* was not observed here.

Royal Observatory, Cape of Good Hope:
1901 *January* 9.

New Form of Reflecting Telescope. By Charles Anthony, jun.

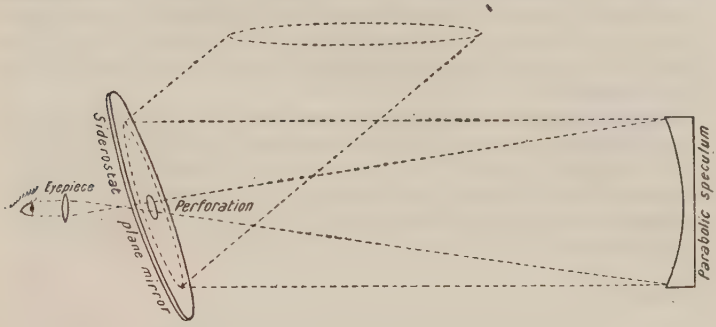
If the writer may be allowed to express his opinion on the best forms of mounting for refracting telescopes he would certainly say that for small and medium-sized ones he considers the movable elbow form to be the best, the observer's position being so eminently comfortable and convenient, and the loss by reflection being limited to one mirror in place of the two required in the original form of telescope coudé.

For large refractors the use of a siderostat, as applied in the large Gautier telescope at Paris, appears by far the best arrangement yet devised. The optical disadvantage is limited, as in the movable elbow form, to one reflection, a point more than compensated for by the observer's easy position.

The mechanical advantages are palpable, the unwieldy tube remaining fixed or being entirely dispensed with ; the portion to be driven by clockwork is thus limited to the plane mirror. The housing of such a telescope is likewise a much easier and cheaper matter than that of a great equatorial.

On the other hand, the improvement in the mounting of great reflectors appears to the writer to have lagged behind sadly in recent years. He therefore begs to bring forward an application of the siderostat, which appears to him to carry with it several concomitant advantages, making it a method even more

satisfactory for great reflectors than refractors. The idea illustrated schematically in the accompanying figure is briefly as follows :—



The speculum is mounted facing the siderostat plane mirror at a distance approximately equal to its focal length from the centre of the latter.

The plane mirror is perforated through its centre, thus allowing the image formed by the speculum to be examined and magnified by an ocular placed immediately behind the siderostat without further reflection by flat or small mirror, as in the Newtonian, Gregorian, or Cassegrainian form of instrument. This method of mounting in the case of reflectors, it will be seen, does not labour under the disadvantage of introducing additional reflections as in the refractor, reflection at the surface of the large plane siderostat mirror simply taking the place of that due to the usual flat or small mirror. It leads to the same comfort in observing, and is for the following reasons especially advantageous in the reflecting form of telescope.

The economy in mounting and housing is very great, as already pointed out in the case of refractors ; and this would lead to the construction of reflectors of greater focal length in proportion to aperture, with the consequent improvement of their definition due to the elimination of the Schaeberlian aberration, which has, in consequence of the shortness of focus necessitated by exigencies of mounting, been only too much in evidence in most recently constructed large reflectors.

Further, the fixing of the speculum in a constant position overcomes the hitherto almost insurmountable difficulty of its flexure under its own weight when moved.

The plane mirror may be mounted as a cœlostat, but at the cost of some inconvenience. It will probably be found better to retain the siderostat method of mounting, modified by some such ingenious device for the mechanical compensation of the rotation of the field as suggested by Professor H. H. Turner in *Monthly Notices*, vol. lxi. p. 122, and H. C. Plummer on p. 402.

This method of mounting, admittedly good for great refrac-

tors, appears, therefore, to the writer even better adapted to reflectors, if modified as suggested by the piercing of the plane mirror, thus permitting of the elimination of the usual small flat or mirror; and he hopes to hear of its application in the near future in the construction of the next great reflector, which is to wrest the supremacy too long held in these latter days by the giant refractors.

In conclusion, he would point out that should it be objected that the close proximity of the observers to the plane mirror might impair the definition, this inconvenience can be overcome with little loss of light by the use of a long eyepiece constructed on the plan of a compound microscope, or by the use of a Barlow lens.

1901 *June* 19.

Note in Reply to Mr. H. C. Plummer's Paper (*Monthly Notices*, vol. lxi. pp. 368–375). By B. Cookson.

Mr. Plummer has pointed out that in the expression deduced on p. 136 for the weight of an observation-equation of a meteor the Q term should be non-existent. As this term is generally small compared with the P term, the weights will be but little altered by its omission, and consequently the values of the unknowns in the equations of condition, which were originally derived, will be only very slightly modified. In order to see how far this is true, some of the original sets of equations have been resolved with the corrected weights, and it is found that in no case is the probable error of beginning and end of path changed by more than $0^{\circ}\cdot02$—a quite insignificant quantity. In the most unfavourable case the coordinates of the radiant are changed by just one-half of their probable error, but in other cases by less than one-fifth of their probable error. The conclusions of the paper are therefore in no way affected. The correct expression for the weight is D^2/P, as indicated by Mr. Plummer, and the quantities printed in italics in the table in my paper are superfluous.

On the Accuracy of Photographic Measures: being a Discussion of a recent Paper by M. Loewy. By H. C. Plummer, M.A.

1. In the eighth Circular of the Conférence Astrophotographique Internationale, recently published, M. Loewy has recorded certain series of measurements on a photographic plate which have been designed and carried out in a definitely experimental spirit. On this material, which is beyond all

question of a most interesting and instructive kind, he has based an elaborate discussion. His conclusions therefrom lead him to formulate a very clearly defined programme of work in connexion with the *Eros* parallax plates. This programme of measurement is a particularly arduous one, and yet M. Loewy's position of deserved authority makes it appear likely that the attempt will be made at not a few observatories to carry out the scheme in its entirety. It is greatly to be feared that this course may entail a considerable delay in the publication of results. Any such effect would be most regrettable and is most strongly deprecated by M. Loewy himself in his introduction to the circular quoted. No excuse is needed therefore for an examination of M. Loewy's arguments and conclusions with a view of justifying if possible a considerable reduction of the proposed scheme of work. If it could be shown that M. Loewy has underestimated the accuracy of photographic measures, and that for an assigned degree of precision a smaller number of measures would suffice, the result would evidently be, to put the matter on the lowest ground, of considerable economic importance. Considerations of this kind have led me to examine M. Loewy's paper in some detail.

2. Of the three parts into which M. Loewy has divided his paper it is with the first only that I propose to deal. In the second he considers the accuracy of measurements which have been effected simply in the réseau lines imprinted on the plate, and in the third generalises his previous conclusions so as to obtain guidance and lay down definite rules for any circumstances that may arise. But at present it will be unnecessary to go beyond the first section.* The material for discussion has been obtained from a single plate bearing a triple image of each object. The number of stars employed is 82, the magnitude varying between 7·0 and 12·5. Each number recorded is a measure of a y-coordinate, and each has been obtained by setting the micrometer thread on the first réseau line, on each of the three images, and on the second réseau line, and then repeating the five settings in the reversed order. Thus each is the result of four settings on a réseau line and six bisections of a star image. Two tables have been formed, each containing eight measures in this sense of all the 82 stars. In Table I the measures were made by an observer A in successive orientations of the plate 0°, 90°, 180°, and 270°, and were similarly repeated by an observer B. In Table II, on the other hand, the measures were made by one of the observers alone and repeated eight times without altering the orientation of the plate.

* I may, however, take this opportunity to point out a slight slip which occurs on p. 24 of the paper. The mean value of $(2f^2-2f+1)$ when f varies from 0 to 1 is not $\frac{1}{2}$, as given, but $\frac{2}{3}$. The fraction $\frac{1}{2}$ is in fact the minimum instead of the mean value. Numerically the correction may be insignificant, but it is fatal to M. Loewy's contention that the combination of measures which is adopted in order to eliminate the effect of distortion of the film has the further advantage of minimising the consequences of accidental error.

3. By subtracting the mean from each group of eight determinations of y M. Loewy has formed the residuals and determined the probable errors. The values he gives are :

For Table I	$0''{\cdot}096$
For Table II	$0''{\cdot}0385$

The disparity is very striking, and its magnitude would hardly have been expected had not M. Loewy's work put the fact so clearly in evidence. That the repetition of measures under exactly similar circumstances would tend to reduce the discordances without increasing the accuracy in proportion is evident on general principles. That the effect of correlation is so noteworthy in this case is, I think, surprising.

4. M. Loewy at once bases on the constants given above a general numerical theory of the errors made in measuring a plate. He distinguishes between two kinds of error, the accidental and what he calls the systematic. The term "systematic" in this connexion is rather unfortunate and perhaps misleading. What is meant is that the irregular outline of an image will create a different impression on the mind of an observer when seen at different times and under different circumstances ; on the other hand, as M. Loewy very rightly says, "l'astronome, ayant défini *à priori* ce qui lui paraît être les centres des deux images à comparer, s'efforcera toujours de les pointer aussi bien que possible en restant fidèle à son interprétation primitive, et commettra une erreur constante qui ne sera pas éliminée par la répétition des pointés." Thus we may admit the existence of a source of error which may be to some extent mitigated by repetition of observations under carefully varied circumstances. This is not altogether what is generally understood by systematic error, by which is more usually meant that class of error which is not subject to the axioms of the Theory of Errors, and cannot, therefore, be eliminated by mere repetition of observations. No one could think of accusing M. Loewy of heresy in an elementary matter of this kind, and yet it is rather difficult to follow him when he says (of the systematic error in his own sense) : "Cette dernière quantité peut encore renfermer, par exemple, les petites variations que peut subir la couche de gélatine elle-même sous l'action des divers agents chimiques." Anomalous effects arising in the process of developing the plate are clearly systematic in the ordinary and not in M. Loewy's sense. Perhaps the sentence quoted is not intended to bear the meaning I have given it, but it is certainly equivocal.

5. We may follow M. Loewy in denoting the accidental and systematic errors by E_a and E_s respectively, and the total probable error by E_t, and admit that $E_t^2 = E_a^2 + E_s^2$. The number of settings on each image in a given position of the

plate is denoted by n and the number of orientations by n'. Then M. Loewy writes down the general formula

$$E_t^2 = E_a^2/n + E_s^2/n'$$

without further explanation. Surely the appropriateness of this formula is not obvious. If for one orientation we have $E_t^2 = E_a^2/n + E_s^2$ it might be expected that when the operation is performed in n' orientations we should have $E_t^2 = E_a^2/nn' + E_s^2/n'$. But in any case the point happens to be unimportant. It will be convenient to denote M. Loewy's formula for E_t by $E(n, n')$. Now the results derived from the two tables of measures give at once

$$E(2, 1) = 0''\cdot096 \text{ and } E_a = 0''\cdot0385 \times \sqrt{2}$$

It follows at once that $E_s = 0''\cdot088$. M. Loewy has then constructed on this basis a table of probable errors for all values of n and of n' from 1 to 10. From this it is an easy matter to select the most economical way of arriving at any required degree of precision. M. Loewy decides in favour of two settings in each of four orientations of the plate and expects a probable error $E(2, 4) = 0''\cdot058$. The labour involved in carrying out this programme will be four times that expended in measuring catalogue plates for the Carte Photographique, and yet if M. Loewy is right the accuracy will not be doubled.

6. Now there are two objections to the validity of M. Loewy's conclusions which suggest themselves quite naturally. They do not as a matter of fact prove substantial, and yet M. Loewy might have disposed of them by anticipation. He has made no reference to the systematic error of personality; and while he has contrasted results obtained jointly by two observers with results obtained by one alone, he has given no justification for supposing that the two are equally skilful and therefore directly comparable. I have been led in consequence to examine these points, but with a negative result. Addition of the residuals according to each observer for each orientation only served to indicate the following constant errors:

	0°	90°	180°	270°
Obs. A	+0''·0001	+·0008	−·0003	−·0005
B	+·0009	−·0001	−·0017	+·0008

These are too small to be of serious account, but they have been removed, as is clearly allowable, before the following errors of mean square were determined:

	0°	90°	180°	270°
Obs. A	0''·0024	·0020	·0024	·0016
B	·0024	·0027	·0022	·0026

These are as well accordant as could have been expected; they lead to a mean probable error 0''·094, which is quite close to

M. Loewy's value. The divergence between the mean probable errors for A and B (0″·08 and 0″·10 respectively) is, however, sufficient to warn us against laying too much stress either on small differences or accidental coincidences between numerical estimates of probable error.

7. There is, however, a striking anomaly which manifests itself in the residuals of B in orientation 90° and 270°, and which deserves mention. If they are summed for the first 52 and last 30 stars separately this is the result :—

	90°	270°
First 52 stars	−0′·0558	+0′·0906
Last 30 stars	+0′·0491	−0′·0294

Or in the mean

−0″·07	+0″·11
+0″·10	−0″·05

This suggests that B's measures in 90° and 270° may have by some means become interchanged in the latter half of the list. It is, of course, impossible to decide at what point this may have taken place. But interchanging the later sums as given we obtain for B's personal equation in these orientations the numbers

−0″·06 +0″·10

And if we now make allowance for these constant errors we shall reduce the errors of mean square to

0′·0024 0′·0022

and so improve the agreement with A. But the total probable error will not be materially altered. The explanation I have suggested may perhaps appear rather fanciful. Yet it seems the only alternative to a conclusion so grave that we should naturally hesitate to accept it. This is that a skilled observer in the course of a series of measures is capable, owing to a sudden breach of continuity in his personality, of introducing and maintaining a constant discordance amounting in this instance to nearly 0″·2.

8. My next step was to compare directly the two means of the measures recorded in Tables I and II of M. Loewy's paper. The result of the comparison is set out in column I of the table given on p. 624. The differences are given in the sense Table II–Table I. There is an indication of a constant error in Table II of about +0′·0009, or the same as that of B in orientation 0°. The identity of the observer is not revealed, and it would be interesting, though not very important, to know whether the coincidence is accidental or not. In order to appreciate the

significance of the table of differences it is necessary to realise that each mean is based on no less than forty-eight bisections of star images. I am not sure whether a second observer is to be reckoned as doubling the number of orientations or merely the number of settings. But whether the probable error to be assigned to means from Table I is E(4, 4) or E(2, 8) does not happen to matter. In either case M. Loewy's theory furnishes a probable error of 0″·102 for the differences between the two means, while a direct determination from the squares of the discordances gives 0″·114. That is to say, M. Loewy's numbers actually underrate if anything the untrustworthy nature of measures effected in a single orientation of the plate.

9. M. Loewy has then exposed a serious source of fallibility in measures of a photographic plate, and we come now more particularly to the consideration of the remedy he has proposed. This consists in altering the position of the plate between successive series of measures. A good idea of the effect of this procedure will be gained by a comparison of the mean of the measures of A and B in orientations 0° and 90° with those effected in orientations 180° and 270°. The discordances are given in column II of the table below. Counting the number of observers as virtually multiplying the number of orientations we derive from M. Loewy's formula the probable error 0″·082 for a difference. On the other hypothesis it is 0″·096 and as actually determined it is 0″·093. We notice at once that column II has a more satisfactory aspect than column I, especially when we consider that the means employed are based on twenty-four bisections, while column I rests on twice that amount of material. So that up to a certain point M. Loewy's theory stands confirmed, and we must admit that a source of error exists which can be mitigated only by increasing the number of orientations. It certainly seemed to me at this stage of my examination that M. Loewy's views were substantially correct, and yet one might hesitate before accepting his practical conclusion that it is necessary to make measures in four orientations. Exact experiments are even yet wanting which would enable us to draw a line of certainty between the exaggerated fears of some and the excessive confidence of others in regard to the accuracy of the photographic method. But systematic error must of necessity and undoubtedly does exist, though we cannot exactly gauge its magnitude. It might then be justly argued that just as M. Loewy has proved that it is unprofitable beyond a certain point to multiply the number of settings in one orientation on account of the tendency of an observer to repeat his own errors, so a limit may be quickly reached to the number of orientations of value proportionate to the labour expended on account of the existence of the systematic error. And, further, just as the remedy for the one danger is to increase the number of orientations, so the remedy for the second difficulty is to employ a large number of plates. The argument may be

rendered numerically definite by a reference to M. Loewy's own table of probable errors. There we find $E(2, 4)=0''\cdot058$ and $E(2, 2)=0''\cdot073$. These are in the ratio of 4 : 5. But when the systematic error is taken into account, even though it be comparatively small, the ratio of the complete probable errors will be much nearer unity. It becomes then a serious question whether it is worth while to double the work of measurement for the sake of so small an advantage. There is one other point which may be alluded to here. The uncertainty which we now see attaches to the mere measurement of a photographic plate will doubtless be regarded by those who are doubtful of the accuracy of the photographic method as strong confirmation of the justness of their scepticism. It may be so. But the advocates of the comparative advantages of direct micrometrical methods may perhaps notice that the argument is rather a double-edged weapon. The magnitude of the uncertainty has manifested itself because it is easy to vary the conditions of observing. But we are just as sharply reminded on the other hand that the mere agreement of observations is a very deceptive guide as to their excellence. It may be something of a scientific platitude to remark that small probable errors may indicate repetition and not avoidance of error, but it is seldom so emphatically enforced as by the material which M. Loewy has put on record.

Table of the Number of Errors between given limits.

Limits.		I	II Numbers.	III
Extreme errors		$-0''\cdot37$	$-0''\cdot46$	None
$-0''\cdot24$	$-0''\cdot18$	4	2	3
$-0''\cdot18$	$-0''\cdot12$	9	3	8
$-0''\cdot12$	$-0''\cdot06$	7	7	17
$-0''\cdot06$	$0''\cdot00$	14	14	21
$0''\cdot00$	$+0''\cdot06$	10	16	19
$+0''\cdot06$	$+0''\cdot12$	10	15	10
$+0''\cdot12$	$+0''\cdot18$	8	13	4
$+0''\cdot18$	$+0''\cdot24$	6	4	0
$+0''\cdot24$	$+0''\cdot30$	6	2	0
$+0''\cdot30$	$+0''\cdot36$	4	3	0
Extreme errors		$+0''\cdot41$	$+0''\cdot37$	None
		$+0''\cdot46$	$+0''\cdot41$	
		$+0''\cdot52$		
Probable errors		$\pm0''\cdot114$	$\pm0''\cdot093$	$\pm0''\cdot057$

10. I come now to a new fact disclosed by the examination of M. Loewy's data, and one which I regard as of great interest

and no little importance. It throws a new light on the whole question and it demonstrates the insufficiency of M. Loewy's formula as a complete representation of the facts. The means were formed of A and B's measures in orientations 0° and 180°, and again in orientations 90° and 270°. The discordances are analysed in column III of the table given above. For the purpose of applying the formula of M. Loewy they are based on just the same material as those appearing in column II, and the resulting probable errors ought to be equal or nearly so. On the contrary they are, as a matter of fact, *absolutely different*! The vast improvement effected by the new grouping of measures is shown much more clearly by the analysis of the discordances than by the mere probable errors, though these latter are of themselves significant enough. Thus our new probable error is exactly half of that given in column I and less than two-thirds of that given in column II. It seems quite possible that M. Loewy's formula may in general apply to results which have been obtained by merely multiplying the orientations at random. But we must now conclude that *by combining measures in orientations* 180° *apart* (i.e. *with the plate reversed*) *we shall effect a much greater improvement of accuracy than by a random choice of orientations.* Before considering the inferences which can be drawn from this principle I set down here some comparison numbers for the three cases :—

	I	II	III
The numerically largest error ...	0".52	0".46	0".23
No. of errors > 0".3	8	6	0
„ „ > 0·2	21	11	3
„ „ < 0·1	35	47	61

This is merely of course a brief epitome of the previous table, but I hope it will assist to place in the strongest possible light the salient features of contrast.

11. Now numbers like these prove with ample clearness that our last mode of grouping the measures must have eliminated some source of error which cannot be removed by combining observations in two orientations at right angles. Hence we can infer something as to the nature of the "systematic error" of M. Loewy, or at least of a considerable part thereof. It must to a great extent *remain constant for each image when the plate is reversed*, for it is eliminated in great part by taking the mean. On the other hand it *cannot be constant either in magnitude or sign from star to star*, since it escaped the search for a truly systematic error. An error possessing these qualities must always be somewhat difficult to detect. Yet serious consequences may follow if we ignore its existence, for in general it will not obey the axioms on which the ordinary theory of errors is founded. In such a case, as indeed in the one under consideration, special precautions are required if we are to avoid its

disturbing effects. I do not mean to say that the whole error, apart from what is purely accidental, can be removed by simply reversing the plate. But so great an improvement can be effected in this way that this method of procedure must be considered a matter of necessity when measures of the highest precision are required. And already the principle has been adopted in practice, although its function has not, I believe, been thoroughly understood. The causes and amounts of the variations of the error in question cannot at present be precisely determined, though they seem clearly to depend in a general way on the character of the photographic image. Some further remarks on this point will be found in § 14 of this note. One suggestion of a practical kind may be put forward here. We may reasonably conjecture that the magnitude of the deviation will be affected by the psychological condition of the observer at the moment. This factor is obviously liable to change; we have already noticed an extremely serious example of the phenomenon in § 7 unless it can be explained away as I have suggested. At any rate it will be of great advantage to curtail as much as possible the interval elapsing between the measures effected in the direct and reverse position of the plate. This consideration will lead us to suppose that a reversing eyepiece may prove an important adjunct to the measuring machine. It is interesting to notice that this feature has been adopted by Mr. Hinks in designing the new Cambridge machine, and that in his description of the instrument (*Monthly Notices*, lxi. p. 448) he says : "A reversing prism in the microscope, by means of which the field of view can be rotated, is very useful in avoiding personality in measurement." Possibly it would not be speaking too strongly to say that some device for achieving the object in view is not merely useful, but indispensable if the highest accuracy is to be obtained.

12. We have now established, as I think, a firm principle on which to proceed. The line of further search is now clear. Evidently we must regard as the unit of measurement, *not* a measure made in a single orientation, *but* the mean of two effected on the plate in the direct and reversed position. If measures are to be multiplied beyond this extent it is not to be supposed that nothing will be gained by changing the orientation. But that question now appears to be rather of subsidiary importance. I have formed the mean residuals according to the basis suggested, and find for the probable values of the divergences from the complete mean :

	0° and 180°	90° and 270°
A	0″·056	0″·049
B	0·061	0·055

from which I deduce the absolute probable errors

A	0″·065	0″·053
B	0·073	0·062

giving o″·063 for the mean. The errors of B, considered in this aspect, are rather worse than A's; but not to insist too strongly on small differences of numbers in a matter of this kind we may estimate the probable error of an observer who makes double measures in both the direct and reversed position of a plate at about o″·06. I believe that the accuracy of measurement at which M. Loewy aims can be substantially obtained with the expenditure of half the labour that he proposes to devote to this object; and if his programme is carried out the probable error arising from the process of measurement alone may be reduced to o″·04, while the result of this increase of accuracy in this one department of the work will not be commensurate by any means with the labour expended.

13. Certain subsidiary comparisons seem to show that the estimates formed of the probable errors of the principal means for A and B are too large rather than too small when combined according to the theory of errors. Let these means be denoted by a_1, a_2, β_1, and β_2. Now we have already found (in column III of the above table) that the probable error of $\frac{1}{2}(a_1+\beta_1-a_2-\beta_2)$ is o″·057, whereas the numbers of the last paragraph give o″·063. So, again, in order to determine whether there would be any advantage to be obtained by combining the means for A in one orientation with those for B in the other the probable error of $\frac{1}{2}(a_1+\beta_2-a_2-\beta_1)$ was determined and found to be o″·062. The probable value of (a_1-a_2) appears to be o″·077, while calculation from our constants would give o″·084. Finally the probable value of $(\beta_1-\beta_2)$ is o″·096, and agrees perfectly with the calculated value. In these last differences, it may be mentioned, thirty are positive and fifty two negative; a fact suggestive of abnormality. As we are here dealing with the principal means we are, of course, independent of the truth or otherwise of the suggestion made in § 7. On the whole, then, we have some evidence that the residual "systematic" error (in M. Loewy's sense) is certainly small after the treatment of the measures which we have been led to adopt.

14. Owing to the peculiar nature of the error mainly under discussion it would be interesting to inquire into its relation to star magnitude. The material contained in M. Loewy's paper is not ample enough to decide this question. But I have rearranged the residuals according to magnitude and derived the following results from the means. The stars here have been placed in three groups, and the number and magnitude given for each.

		31 stars. > 12	41 stars. < 12, > 10	10 stars. < 10, > 7
	°	″	″	″
A	0	−0·05	+0·02	+0·10
	180	+0·03	−0·01	−0·19
	90	+0·01	+0·04	+0·17
	270	−0·02	−0·02	−0·08

		31 stars. >12	41 stars. <12, >10	10 stars. <10, >7
B	0°	+0″·04	+0″·05	+0″·16
	180	−0·05	−0·11	−0·17
	90	−0·07	+0·03	+0·01
	270	+0·11	+0·01	0·00

The material is scanty, and more reliable evidence is to be desired; and yet a glance will reveal a very distinct tendency towards a progressive change of about 0″·04 per magnitude. The quantity is small certainly, and doubtless negligible in Astrographic Chart work; but in our discussion it is of the same order as the small quantities with which we have been dealing in forming the probable errors. The matter seems quite worthy of further study. At the same time when ampler data are available it would be interesting also to examine the relation of precision to star magnitude. Under the present circumstances it has seemed to me unprofitable to attempt a solution of this question.

15. *Summary of conclusions:*

(1) M. Loewy's contention with regard to the fallibility of measures made in a single orientation of the plate is substantially correct. The facts can *not* be explained by a constant personality or by the inferiority of one of the observers.

(2) A certain improvement in the accuracy of the result can be reached by measuring in different orientations (such as 0° and 90°).

(3) If M. Loewy's estimate of the precision of measures so made be accepted, it does not follow that it is worth while to repeat the measures as many times as he thinks necessary.

(4) By combining measures made in the direct and reversed position of the plate a much better result is obtained to which M. Loewy's formula does *not* apply.

(5) Sufficient accuracy will be obtained by making double measures in these two positions of the plate, and *the labour demanded by M. Loewy may be reduced by one-half.*

(6) The error eliminated by reversing the plate is definite for each image, but may vary both in magnitude and in sign from one star to another.

(7) Some means of reversing quickly is desirable, in case this definite error is liable to change with lapse of time.

(8) The probable error of the mean of double measures made in orientations differing by 180° is about 0″·06. The residual error (other than the accidental) is small, and up to a certain point measures in this sense will obey the ordinary laws of accidental error.

(9) There is some evidence that personality varies considerably according to star magnitude.

University Observatory, Oxford:
1901 *September* 5.

The Green Flash at Sunset.

By Professor William H. Pickering.

(*Communicated by the Secretaries.*)

As an independent confirmation of the observations described in Mr. Franklin-Adams's paper published in the *Monthly Notices* for May 1901 I would say that in the early part of last June I was watching the Sun set from the deck of a steamer not far from the coast of Cuba. At the instant that the Sun disappeared its last ray suddenly turned from red to a distinct blue. The effect was very striking, and I turned to the first officer of the steamer, who was standing beside me, and asked him if he noticed it. He replied that he did, and that he had never observed it before. The sea was very smooth at the time, and I did not notice the appearance resembling Baily's beads.

Mandeville, Jamaica, W.I.
1901 *July* 3.

Note on Two Stars in the Revised Madras Star Catalogue for 1835.

By A. M. W. Downing, D.Sc., F.R.S.

Dr. Herman S. Davis, who is engaged on the re-reduction of Piazzi's observations, has called my attention to certain errors in Piazzi's Catalogue affecting two stars in the Madras Catalogue. I am much obliged to Dr. Davis for his kindness in communicating these particulars to me.

No. 5835. This is really Piazzi xii. 169. Piazzi has the wrong sign for the declination in his catalogue.

No. 8791. Piazzi's declination is in error by $3'\ 40''$ on account of his adopting as the place of one star the mean of the observations of the two stars A. G. C. Leipzig II. Nos. 9075 and 9081, with the R.A. of the former of which Piazzi's R.A. agrees.

Taylor obtained one observation of the declination of Leipzig II. No. 9075, at the date 1836·56, with concluded result $+7°\ 51'\ 31''{\cdot}49$. The corresponding R.A. is $19^h\ 3^m\ 0^s{\cdot}23$, with precession in R.A. $+2^s{\cdot}894$.

These results should be substituted for those in the revised catalogue.

Taylor was misled by Piazzi's erroneous declination, and apparently observed in declination a faint star not far from the erroneous place.

Observations of Comet 1901 I. *observed at Perth Observatory, Western Australia.*

(*Communicated by W. Ernest Cooke, Government Astronomer.*)

The first record of the appearance of the comet seems to come from the natives in the Balladonia District (south coast), who saw it on the early morning of April 22. They reported it to the telegraph master at Balladonia on that day, and again on the 23rd, and he saw it on the 24th, but did not wire particulars. On the morning of the 24th, however, Mr. Tattersall, head keeper of Cape Leeuwin Lighthouse, noticed and reported a bright comet in the east about 6 A.M. I was in Adelaide at the time, and visited the observatory next morning (25th) and succeeded, in conjunction with Sir Charles Todd, in obtaining glimpses between the clouds and measuring a rough position by means of the equatorial circles. This, I believe, was the first observation made anywhere. It was then so bright that its tail, a triple one, could be seen almost up to sunrise, and its nucleus was visible in the 8-inch telescope for some time after the Sun was above the horizon. Unfortunately it was densely overcast during the remainder of the day, otherwise I think I might have been able to determine its position with the transit circle. It was then rapidly approaching the Sun. In Perth the mornings were densely cloudy until Saturday, April 27, when the first approximate position was obtained ($1^h\ 53^m\ 50^s$ R.A. and 88° 42′ N.P.D.) by means of the circles, but the sky was altogether too bright to obtain a photograph. The only note made as to its physical appearance was, "Comet bright, with two distinct tails." The next two mornings (28th and 29th) were brilliantly clear, but no sign of the comet was visible, although the observer examined the eastern horizon carefully with a good pair of field glasses. On the evening of May 1 it was observed low down near the western horizon, and two photographs (1^m and 10^m exposure) were obtained with the astrographic telescope. From this date until it was lost in the moonlight a long and a short exposure photograph were taken every evening when the state of the weather permitted. On some occasions the comet was just glimpsed for a few seconds, and only circle readings were taken. All the observations were made and plates measured by Mr. Johns, who has had several years' experience at astrographic work at both Greenwich and the Cape, and I think the measures can be taken as accurate, on the whole, to within $0''{\cdot}5$. With regard to the reductions I am not quite so certain. I have not had the time to obtain plate constants, and in some of the earlier plates it would not be possible, owing to the lack of stars. I have every reason, however, to believe that the orientation of the réseau was very correct. As to the scale value of the réseau, I have applied a correction of $-\frac{1}{250}$ to every difference. This was

obtained from an independent investigation, and appears to be corroborated, *on the average*, by the present stars. I have, of course, reduced my réseau coordinates to R.A. by the usual formula, and corrected for curvature, but *not* for differential refraction and aberration.

The discordances amongst the individual results appear to me to be large, but they do not seem to indicate any systematic error of reduction. They may be, and probably are, due to wrong positions for the stars at 1901·0, either through inaccuracies in the original observations, or else proper motion. I think, however, that the mean of the positions obtained for each day will be a good determination of the comet's place.

Position of Comet a 1901 *from Photographs.*

Date G.M.T. d h m s	Name of Object.	Rect. Coords. R.A.	Dec.	Mean Pos. of stars 1901·0. R.A. h m s	N.P.D. ° ′ ″	*dα.* m s	*dδ.* ′ ″	Mean Pos. ☄ 1901·0. R.A. h m s	N.P.D. ° ′ ″
May 1 22 34 32	☄	42·967	13·800						
	4165 P.	30·531	15·361	3 26 0·94	90 49 7·8	−4 8·74	− 7 46·4	3 21 52·20	90 41 21·4
3 22 23 37	☄	43·174	13·854						
	4537 P.	53·528	26·729	3 47 7·13	91 26 43·2	+3 26·33	−64 7·1	3 50 33·46	90 22 36·1
	4540 P.	53·157	20·788	3 47 14·10	90 57 8·7	+3 18·90	−34 31·9	33·00	36·8
4 22 29 41	☄	42·751	11·970						
	4803 P.	43·150	4·405	4 3 36·38	89 28 39·8	+ 7·95	+37 40·4	4 3 44·33	90 6 20·2
	4810 P.	41·775	11·690	4 4 4·24	90 5 0·1	− 19·44	+ 1 23·6	44·80	23·7
	4858 P.	34·595	18·855	4 6 28·51	90 40 44·9	−2 42·47	−34 17·2	46·04	27·7
5 22 25 42	☄	43·305	14·081						
	4844 A.	44·002	18·607	4 15 45·29	90 9 38·3	+ 13·89	−22 32·4	4 15 59 18	89 47 5·9
	1280 A. G. (1)	43·330	5·125	4 15 58·22	89 2 31·2	+ 0·50	+44 36·1	58·72	7·3
	688 G.	42·100	20·636	4 16 23·39	90 19 47·6	− 24·00	−32 38·7	59·39	8·9
6 22 26 1	☄	43·590	14·086						
	5220 P.	45·387	24·051	4 26 48·84	90 15 23·1	+ 35·80	−49 37 6	4 27 24·64	89 25 45·5
	1329 A. G. (1)	44·295	5·130	4 27 9 81	88 41 7·6	+ 14·04	+44 36 1	23·85	43·7
	725 G.	43·884	11·702	4 27 18·24	89 13 50 6	+ 5·86	+ 11 49·3	24·10	39 9
	729 G.	40·515	11·164	4 28 25·45	89 11 10·8	−1 1·26	+ 14 31·1	24·19	41·9

Date G.M.T. d h m s	Name of Object.	Rect. Coords. R.A.	Dec.	Mean Pos. of stars 1901·0. R.A. h m s	N.P.D. ° ′ ″	$d\alpha$ m s	$d\delta$ ′ ″	Mean Pos. ☄ 1901·0 R.A. h m s	N.P.D. ° ′ ″
May 7 22 24 28	☄	43·059	14·130						
	1378 A. G. (1)	43·360	14·478	4 37 54·03	89 4 47·1	+1 6·00	− 1 44·2	4 38 0·03	89 3 2·9
	1386 A. G. (1)	40·885	11·260	4 38 43·33	88 48 43·6	− 43·31	+14 17·6	0·02	1·2
	5437 P.	38·200	20·924	4 39 37·14	89 36 52·1	−1 36·79	−33 50·0	0·35	2·1
8 22 23 32	☄	43·290	13·910						
	1453 A. G. (1)	45·550	13·852	4 47 5·01	88 39 22·6	+ 45·02	+ 0 16·7	4 47 50·03	88 39 39·3
	1462 A. G. (1)	41·717	18·397	4 48 21·78	89 2 1·8	− 31·34	−22 20·7	50·44	41·1
	1467 A. G. (1)	40·376	13·091	4 48 48 20	88 35 35·1	− 58·07	+ 4 4·7	50·13	39·8
12 22 18 35	☄	43·091	13·910						
	1712 A. G. (1)	45·083	14·751	5 20 0·79	87 10 39·2	+ 39·74	− 4 11·3	5 20 40·53	87 6 27 9
	1720 A. G. (1)	41·092	14·421	5 21 20·43	87 9 2·2	− 39·88	− 2 32·6	40·55	29·6
	1723 A. G. (1)	40·158	12·490	5 21 39·04	86 59 23·9	− 58·51	+ 7 4·3	40·53	28·2
13 22 20 3	☄	43·145	13·895						
	1779 A. G. (1)	47 634	14·438	5 26 2·77	86 46 58·9	+1 29·54	− 2 41·9	5 27 32·31	86 44 17·0
	1797 A. G. (1)	41·891	16·319	5 27 57·63	86 56 22·6	− 25·02	−12 4·3	32·61	18·3
	1801 A. G. (1)	39·125	17·175	5 28 52·74	87 0 38·5	−1 20·20	−16 19·8	32·54	18·7
14 22 44 52	☄	43·165	13·906						
	1834 A. G. (1)	43·460	8·606	5 33 57·52	85 56 6·2	+ 5·88	+26 23·6	5 34 3·40	86 22 29·8
	1835 A. G. (1)	42·590	17·079	5 34 15·20	86 38 17·7	− 11·47	−15 48·1	3·73	29·6
	1849 A. G. (1)	36·652	12·667	5 36 13·71	86 16 22·6	−2 10·06	+ 6 10·8	3·65	33·4

Date G.M.T. d h m s	Name of Object.	Rect. Coords. R.A.	Rect. Coords. Dec.	Mean Pos. of stars 1901·0. R.A. h m s	Mean Pos. of stars 1901·0. N.P.D. ° ′ ″	$d\alpha$ m s	$d\delta$ ′ ″	Mean Pos. R.A. h m s	Mean Pos. 1901·0. N.P.D. ° ′ ″
May 16 22 27 1	☄	43·110	13·910						
	1913 A. G. (1)	45·055	12·731	5 44 58·63	85 36 20·2	+ 38·86	+ 5 52·3	5 45 37·49	85 42 12·5
	1923 A. G. (1)	42·842	15·041	5 45 43·08	85 47 49·0	− 5·34	− 5 37·6	37·74	11·4
	1928 A. G. (1)	40·420	13·490	5 46 31·30	85 40 4·9	− 53·75	+ 2 5·5	37·55	10·4
19 22 41 13	☄	42·955	13 914						
	2607 A. G. (2)	45·940	11·409	5 59 51·48	84 34 28 9	+ 59 72	+12 28·8	6 0 41·20	84 46 57·7
	2616 A. G. (2)	43·255	7·550	6 0 35·16	84 15 14·9	+ 5·98	+31 42·5	41·14	57·4
	2029 A. G. (1)	36·225	16 644	6 2 56·12	85 0 34·9	−2 14·66	−13 34·9	41·46	60·0
	2031 A. G. (1)	36·035	17·397	6 2 59·98	85 4 22·1	−2 18·46	−17 19 8	41·52	62·3
22 22 56 47	☄	43·245	13·950						
	2772 A. G. (2)	46·210	15·961	6 12 22·34	84 8 42·3	+ 59·38	−10 0·6	6 13 21·72	83 58 41·7
	2781 A. G. (2)	45·073	14·734	6 12 45·16	84 2 34·7	+ 36·63	− 3 54·0	21·79	40·7
	2791 A. G. (2)	42·744	17·836	6 13 32·05	84 18 2·4	− 10·04	−19 22·1	22·01	40·3
23 22 51 8	☄	42·935	14·040						
	2815 A. G. (2)	48·272	19·731	6 15 30·82	84 12 55·7	+1 46·83	−28 19·6	6 17 17·65	83 44 36·1
	2824 A. G. (2)	46·438	10·931	6 16 7·12	83 29 4·1	+1 10·16	+15 29·3	17·28	33·4
	2843 A. G. (2)	43·428	21·657	6 17 8·13	84 22 31·3	+ 9·88	− 37 56·0	18·01	35·3
	2860 A. G. (2)	39·435	16·380	6 18 27·83	83 56 12·0	−1 10·08	−11 38·9	17·75	33·1
	2883 A. G. (2)	35·208	3·397	6 19 52·41	82 51 36·1	−2 35·16	+53 1·6	17·25	37·7

Date G.M.T. d h m s	Name of Object.	Rect. Coords. R.A.	Rect. Coords. Dec.	Mean Pos. of stars 1901·0. R.A. h m s	Mean Pos. of stars 1901·0. N.P.D. ° ′ ″	$d\alpha$ m s	$d\delta$ ′ ″	Mean Pos. ☄ 1901·0. R.A. h m s	Mean Pos. ☄ 1901·0. N.P.D. ° ′ ″
May 25 22 37 18	☄	42·950	13·851						
	2939 A. G. (2)	45·520	12·663	6 23 32·50	83 10 25·0	+ 51·38	+ 5 55·2	6 24 23·88	83 16 20 2
	2948 A. G. (2)	42·376	8·440	6 24 35·27	82 49 20·8	− 11·71	+26 56·8	23·56	17·6
	2956 A. G. (2)	41·743	11·071	6 24 48·16	83 2 28·8	− 24·42	+13 50 6	23·74	19·4

	d h m	R.A. h m s	N.P.D. ° ′
Apr.	26 10 1	1 53 50	88 42
	31 22 25	3 6 12	90 46
May	9 22 30	4 57 8	88 6
	11 22 30	5 13 15	87 29
	17 22 30	5 51 18	85 20
	18 22 49	5 56 22	85 2
	20 22 45	6 5 31	84 29
	24 23 31	6 21 15	83 30
	27 23 0	6 31 7	82 51
	30 23 3	6 40 17	82 17
	31 22 59	6 42 36	82 6

Circle readings only, taken when the comet was seen between the clouds for a few seconds only. Probably correct to within about a minute of arc in either coordinate.

P. = Paris, G. = Greenwich 1880, A. = Argentine Genl., A. G. (1) Astron. Gesell., + 1° to + 5°, and (2) + 5° to + 10°.

Perth Observatory: 1901 *June* 24.

Errata in Mr. Cookson's Paper on a Floating Photographic Zenith Telescope

Page 316, line 11, *for* divining *read* devising.

„ 322, „ 5, *for* $\delta\phi$ *read* $2\delta\phi$.

„ 322, „ 4 from bottom, *for* ten *read* the.

„ 326, „ 6, Heading of Table should be:

	Mean Diff. Photograph and Scale in 0·0001 mm.	
	5 mm.	15 mm.

„ 327, „ 5 from bottom, *for* degrees *read* grammes.

„ 328, lines 1 and 4, *for* degrees *read* grammes.

„ 330, line 21 from bottom, *for* but *read* from.

„ „ „ 17 „ „ *for* and from *read* but for.

„ „ „ 16 „ „ dele "probable error due to error of."

Errata in Cape Observations of the Great Comet of 1901, *page* 510.

May 4, *for* $29^s{\cdot}23$ *read* $24^s{\cdot}23$.

May 5, *for* $9^s{\cdot}97$ *read* $8^s{\cdot}97$.

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"Preliminary Determination of the Wave-lengths of the Hydrogen Lines, derived from Photographs taken at Ovar at the Eclipse of the Sun, 1900, May 28."

By F. W. DYSON, M.A., Sec. R.A.S. Communicated by W. H. M. CHRISTIE, C.B., M.A., F.R.S. Received January 17,—Read February 7, 1901.

The spectrum of the "flash" obtained in observations of solar eclipses furnishes a method of determining the wave-lengths of the hydrogen series with great accuracy, as these lines are strongly shown and sharply defined. As the determination of these wave-lengths is somewhat removed from the general subject of eclipse spectroscopy, it seemed suitable for a separate paper.

The following determination is made from four photographs taken near the beginning of totality at Ovar, at the eclipse of 1900, May 28,

in the expedition from the Royal Observatory, Greenwich. The spectroscope used is a four-prism quartz spectroscope, kindly lent by Captain Hills. The length of the spectrum from h (λ 4102) to the limit of the hydrogen series (λ 3640) is 40 mm., so that the scale is about 10 tenth-metres to the millimetre.

The spectra were measured with one of the astrographic micrometers of the Royal Observatory (a micrometer originally designed for measuring the photographs taken at the transit of Venus) by comparison with a glass scale divided to millimetres. The errors of the 5-mm. divisions have been accurately determined in the course of investigations of the errors of the réseaux used in the photographic chart of the heavens. The errors of the intermediate divisions were determined by Mr. Davidson. The value of one revolution of the screw of the micrometer is approximately $\frac{1}{3}$ mm.

The wave-lengths were deduced from the measures by an interpolation formula, derived principally from the following lines, whose wave lengths are taken from Rowland's tables :—

Ca	3968·625	Ti.....	3761·464
Ca	3933·825	Ti.....	3759·447
Ti	3913·609	Cr Ti ...	3757·824
Ti	3900·681	Ti.....	3741·791
Mg	3838·435	Ti Fe ...	3722·729
Mg	3832·450	Y	3710·431
Mg	3829·501	Ti.....	3685·339
Y.....	3788·839	Fe Ti ...	3659·901
Y.....	3774·473		

These lines are the strongest lines in this part of the "flash" spectrum. In some of the photographs a number of the strongest iron lines were also used as lines of reference. On the photographs taken a few seconds before the eclipse became total the iron lines are unsuitable as lines of reference, as in some cases both a bright line and an absorption line are seen, and in other cases the lines have a grey appearance, and are not sharp and clear like the lines given above.

The wave-length of h is only derived from one photograph, and is not determined accurately. The value obtained agrees with the result given by Mr. Wright,* in showing a correction of 0·1 of a tenth-metre to the value given by Rowland.

The intensities of the lines are given somewhat roughly. With the exception of the cases noted where other lines apparently interfere, the diminution of intensity is sensibly uniform.

A comparison has been made with the wave-lengths given by Balmer's law, using the formula $\lambda = 3646{\cdot}140 \frac{n^2}{n^2-4}$, the constant of

* 'Astroph. Journ.,' vol. 9.

which agrees very closely with the wave-lengths of the three lines H_α, H_β, H_γ given by Rowland. No correction to the formula has been deduced, as only a small one is indicated, and it is desirable to use a larger number of lines of reference than has been employed in this investigation. The wave-lengths were determined from each series of measures separately, and from the accordance of these the probable errors of the resulting determination of wave-lengths lie between $\pm 0{\cdot}01$ and $\pm 0{\cdot}02$ of a tenth-metre for the different lines.

Hydrogen line.	Int.	*n*.	Observed wave-length.	Wave-length by Balmer's law.	Diff.	Remarks.
δ	40	6	4101·88	·907	+ ·03	Only measured on one photograph.
ε	40	7	3970·229	·241	+ ·012	
ζ	60	8	3889·101	·216	—	Helium line at 3888·785 not separated.
η	40	9	3835·540	·550	+ ·010	
θ	30	10	3798·057	·063	+ ·006	
ι	30	11	3770·765	·794	+ ·029	
κ	25	12	3750·322	·315	− ·007	
λ	18	13	3734·565	·531	− ·034	Touching Fe line at 3735·014.
μ	18	14	3722·060	·101	+ ·041	
ν	16	15	3712·109	·133	+ ·024	
ξ	16	16	3703·981	·015	+ ·034	
o	15	17	3697·283	·313	+ ·030	
π	13	18	3691·670	·717	+ ·047	
ρ	11	19	3686·950	·992	+ ·042	
σ	9	20	3682·954	·967	+ ·013	
τ	7	21	3679·483	·514	+ ·038	
υ	6	22	3676·568	·525	− ·043	3676·457 Fe Cr } probably 3676·698 Co } interfere.
ϕ	4	23	3673·914	·920	+ ·006	
χ	5	24	3671·574	·638	+ ·064	Probably Zr 3671·412 interferes.
ψ	3	25	3669·595	·625	+ ·030	
ω	1	26	3667·891	·843	− ·048	
α'	2	27	3666·185	·256	+ ·071	
β'	4	28	3664·770	·838	+ ·068	Partly due to Y at 3664·760.
γ'	1	29	3663·565	·553	− ·012	
δ'	5	30	3662·373	·418	+ ·043	Mainly due to Ti at 3662·378.
ε'	1	31	3661·475	·380	− ·095	Possibly 3661·509 Fe interferes.

"On the Brightness of the Corona of January 22, 1898. Preliminary Note." By H. H. TURNER, D.Sc., F.R.S., Savilian Professor. Received January 18,—Read February 7, 1901.

1. In a former note* I gave some account of measures of brightness made on photographs of the corona of 1893 by Abney's method. The same method has been used on the coronal photographs taken in 1898 and in 1900 (in 1896 none were obtained owing to cloud), and a large number of measures have been made, though the work is not yet complete. Pending the completion and publication of this work, it seems advisable to publish the present note, as one or two results have been arrived at which may be useful to others in the forthcoming eclipse.

2. As regards the method of measurement, sufficient has been said (for the present purpose) in the paper already quoted. It need only be added that in place of the revolving sectors a graduated wedge of gelatine was used to diminish the comparison beam, according to Sir W. Abney's more recent methods. The wedge or sectors are mere intermediaries between the coronal image and the standard squares, and no considerations beyond those of convenience are involved. The wedge is much more convenient, and the work can be done with it twice as rapidly.

3. But a new method has been adopted of representing the results, which, though an elementary change in some respects, has had the important consequence of suggesting a more satisfactory law for the variation of coronal brightness with distance from the sun. The only simple law (so far as I am aware) which has hitherto been formulated was that proposed by Professor Harkness in 1878, viz. :—

$$\text{Brightness} \propto (\text{distance from sun's limb})^{-2}.$$

Visual measures made by Thorpe and Abney in 1886 and 1893 could not be reconciled with this law; though I showed in the paper already quoted that if the distance be measured from a point *within* the limit (about $\frac{1}{5}$ radius within), the law approximately satisfied the photographic measures.

I have now been led to a completely new law, viz. :—

$$\text{Brightness} \propto (\text{distance from sun's } \textit{centre})^{-6},$$

which, though still on trial, is supported by a fair amount of evidence, and the suggestion arose in the following way :—

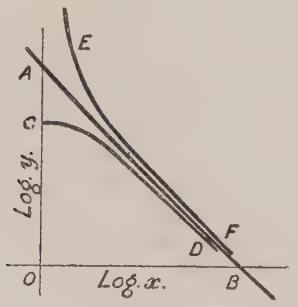
4. The brightness curve in the previous paper was obtained by plotting brightness against distance. This gives a curve of hyperbolic

* 'Roy. Soc. Proc.,' vol. 66, p. 403.

form close to the two axes of reference, and difficult to compare the observations with, for reasons which are tolerably obvious. The curve is still hyperbolic if log (brightness) be plotted against distance; but if the brightness varies as any power of the distance, and we plot log (brightness) against log (distance), we get a straight line, which is particularly easy to compare observations with. The only difficulty is that we must know where to measure our distance from; for if we add or subtract a constant to the distance, it will change the straight line into a curve. And unfortunately the point from which the distance was to be measured seemed just one of the things to be determined.

5. But after some preliminary experiments I found that it was not difficult to find the proper origin from which to measure the distance, by the very condition that the curve was to be a straight line.

Fig. 1.



If in the equation

$$\log y + n \log x = \text{const.}$$

represented by the straight line AB in fig. 1, we write $(x + \alpha)$ for x, then the calculated values of $\log y$, when x is large compared with α, will be nearly the same as before; but when x is small $\log (x + \alpha)$ will be increased, and $\log y$ therefore diminished, and we get a curve such as CD. (If α be negative, we get a curve such as EF.) And a very few trials (perhaps one alone suffices) give the value of α, which will straighten the curve.

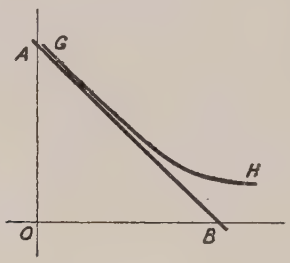
6. These values immediately pointed to the sun's centre as the proper origin for measurement; and when the observations were plotted on this assumption, the curve was practically a straight line, and the slope of this line indicated that the index n was 6, giving the law already stated, viz.:—

$$\text{Brightness} \propto (\text{distance from sun's centre})^{-6}.$$

7. But one further point is to be noted. The curve was practically straight for some distance from the limb, but then always turned

upwards like the curve GH in fig. 2. Now comparing this with CD in fig. 1, it suggests that just as CD could be explained by the addition of a constant to the *distance*, which made a variable alteration in the log distance, so GH may be explained by the addition of a constant to

FIG. 2.



the *brightness*, making a variable alteration in the log brightness. And there is a possible physical cause for this constant addition, viz., the general sky illumination or glare which is added to the coronal brightness. A value of about 0·012 of the average brightness of the full moon for this illumination seems to satisfy requirements for the 1898 photographs.

8. I proceed to give a brief summary of the measures on the photographs of 1898 so far as they have gone.

Four photographs have been selected for measurement, three of them taken by me at Sahdol with exposures of 1 sec., 2 secs. and 20 secs., and one taken by Capt. Hills at Pulgaon with exposure 8 secs. On these, measures have been made along six radii extending approximately N., S., E., W., N.E., and S.W., the last two being as nearly as possible in the direction of the main streamers.

9. The exposures given to the standard squares were all the same. These squares transmit fractions of the light ranging from 0 to 4 on a scale of powers of 2, a range which might be extended with advantage, seeing that measures on the corona can be profitably made over a range of 0 to 7 at least. But the smallness of the range is made up for in practice by the measurement of photographs with different exposures. Thus the longer exposures of 20 secs. and 8 secs. in the above series control the fainter parts of the corona, and the shorter of 1 sec. and 2 secs. control the brighter parts near the limb.

10. In comparing the results from the different plates, it is found that the brightnesses shown by one plate differ from those shown by another in a constant *ratio*. Since the log (brightness) is tabulated this means a constant *difference* between similar numbers for the two plates. Following Sir W. Abney's practice, I have used the base 2 for the logarithms of brightness, and recorded to 0·1, which represents a

ratio of $2^{0\cdot1} = 1\cdot07$. (The logarithms of distance have been taken to base 10 in the ordinary way.) These differences between the plates may be due to any combination of the following causes:—

(*a*.) Accidental error in exposure to corona. The exposures were made without any mechanism, and the short ones especially may be sensibly in error. Thus the difference between the 1 sec. and 20 secs. exposure is 0·8. If the whole of this be due to accidental error in the 1 sec. exposure, it would mean that the exposure was for 1 sec. $\times 2^{-0\cdot8}$ = 0·58 sec. instead of for 1·0 sec., which is not an extravagant supposition.

(*b*.) Accidental error in exposure to squares. This should be much smaller than (*a*.).

(*c*.) Difference in sensitiveness of the film near the edge of the plate where the squares are impressed, and in the centre where the corona is impresssed. There is independent evidence of sensible differences of this kind, and the point is under investigation.

(*d*.) Differences in the behaviour of the candle which impressed the squares on the various plates.

(*e*.) Climatic differences between Sahdol and Pulgaon.

11. It becomes necessary to decide which plate to take as the standard. Cause (*a*.) ought not to affect the 8 secs. and 20 secs. appreciably, but cause (*e*.) may. They differ by 0·5, and we may perhaps take the mean. The corrections to be applied to the plates are then

Plate	I	II	III	IV
Exposure.....	1 sec.	2 sec.	8 sec.	20 sec.
Place	Sahdol	Sahdol	Pulgaon	Sahdol
Correction ...	+0·6	−0·2	+0·3	−0·2

If any other selection is preferred, it is easily applicable as a constant to the final numbers.

12. The correction for constant illumination of the plate due to sky-glare has been adopted as $2^{-6\cdot4}$ moon, taking the moon as equal to 0·02 of a candle at 1 foot. If at any point the corona has a brightness represented by x, meaning $2^x \times$ moon, then the brightness measured on the plate will appear as y where

$$2^x + 2^{-6\cdot4} = 2^y.$$

A table was formed giving y in terms of x, of which the following is a portion:—

x.	Correction to x.	y.
−2·0	0·0	−2·0
−3·0	+0·1	−2·9
−4·0	+0·2	−3·8
−5·0	+0·4	−4·6
−6·0	+0·8	−5·2
−7·0	+1·3	−5·7
−8·0	+2·0	−6·0

13. The measures on the plates were then corrected—

(*a*.) For the particular plate, as in § 10 ;
(*b*.) For the sky-glare, as in § 11 ;

and compared with the curve

$$\text{brightness} \times (\text{distance})^6 = \text{A}$$

to get the value of the constant A for each of the six radii measured. As above explained, the curve used was a straight line, obtained by plotting log brightness as ordinate and log distance as abscissa. The constants found for the six radii were as follows—adopting as unit of brightness that of the moon (assumed 0·02 candle at 1 foot), and of distance that of the sun's radius, so that the constants represent the brightness of the corona at the sun's limb expressed in moons :—

Radius.	N.	N.E.	E.	S.	S.W.	W.	Mean.
A =	+0·4	+1·9	+1·7	0·0	+2·3	+0·6	+1·15

Thus at the sun's limb the corona is more than twice as bright as the full moon on the average.

14. Finally, the individual measures were compared with the adopted law, with the following results. In the column "Typical Curve" the calculated brightness is given for A = + 0·6, the actual figures for the different streamers differing from this throughout by constants which are easily inferred from the values of A given above.

Table I.—Comparison of Observed Brightness (Photographic) of 1898 Corona with the Law.

Brightness × (distance from Sun's centre)^6 = constant.

(The distances were measured in divisions of 13 to the Sun's radius. The brightnesses are expressed by powers of 2, zero representing Moon's brightness.)

Distance from Sun's centre in radii.	Typical brightness of corona alone.	Typical brightness with "glare" added.	Observed error of formula.						
			Plate.	N.	N.E.	E.	S.	S.W.	W.
1·08	+ 0 1	+0·1	I	+0·6	—	−0·1	+0·7	—	+0·4
1·15	− 0·4	−0·4	I	+0·6	−0·1	0·0	+0·4	−0·7	+0·4
1·23	− 1·0	−1·0	I	+0·2	—	−0·1	+0·2	−0·4	0·0
1·31	− 1·5	−1·5	I	+0·5	+0·1	+0·2	−0·2	−0·3	+0·1
1·38	− 2·0	−2·0	I	−0·4	—	0·0	0·0	0·0	+0·1
1·46	− 2·5	−2·4	I	0·0	+0·1	−0·5	+0·3	−0·1	−0·1
1·61	− 3·3	−3·1	I	−0·3	−0·5	−0·7	—	0·0	—
1·77	− 4·1	−3·8	I	—	−0·1	—	—	+0·2	—
1·92	− 4·9	−4·4	I	—	−0·1	—	—	+0·2	—
1·31	− 1·5	−1·5	II	+0·3	—	—	−0·1	—	—
1·38	− 2·0	−2·0	II	0·0	—	—	−0·3	—	+0·2
1·46	− 2·5	−2·4	II	−0·2	—	—	−0·5	—	−0·1
1·54	− 2·9	−2 8	II	−0·3	+0·5	+0·6	−0·3	—	−0·2
1·61	− 3·3	−3·1	II	−0·4	+0·1	+0·2	−0·3	+0·3	−0·2
1·77	− 4·1	−3·8	II	−0·2	−0·2	+0·1	−0·1	−0·1	−0·1
1·92	− 4·9	−4·4	II	—	−0·2	+0·1	—	+0·1	—
2·15	− 5·8	−5·1	II	+0·1	−0·3	+0·1	—	+0·2	—
2·54	− 7·2	−5·8	II	—	—	—	—	+0·3	—
1·46	− 2·5	−2·4	III	0·0	—	—	+0·1	—	—
1·61	− 3·3	−3·1	III	0·0	—	—	+0·1	—	0·0
1·77	− 4·1	−3·8	III	+0·1	+0·4	+0·2	+0·1	0·0	−0·1
1·92	− 4·9	−4·4	III	−0·1	+0·2	+0·2	+0·1	+0·1	−0·2
2·15	− 5·8	−5·1	III	−0·1	0·0	−0·1	+0·1	0·0	0·0
2·54	− 7·2	−5·8	III	+0·2	+0·2	+0·1	—	0·0	0·0
2·92	− 8·5	−6·1	III	—	+0·4	0·0	—	−0·1	—
1·92	− 4 9	−4·4	IV	+0·1	—	—	+0·3	—	—
2·08	− 5·5	−4·9	IV	+0·2	−0·4	—	+0·4	—	+0·4
2·23	− 6·1	−5·3	IV	+0·2	−0·2	0·0	+0·4	—	+0·2
2·38	− 6·7	−5·6	IV	—	−0.2	+0·1	—	0·0	+0·2
2·54	− 7·2	−5·8	IV	+0·2	−0·2	0·0	+0·5	0·0	+0·2
2·92	− 8·5	−6·1	IV	−0·1	−0·2	+0·1	+0·3	0·0	+0·3
3·31	− 9·6	−6·3	IV	—	−0·1	+0·1	+0·1	−0·1	0·0
3·69	−10·5	−6·3	IV	—	−0·2	0·0	—	−0·3	—
4·08	−11·4	−6·4	IV	—	−0·4	—	—	−0·3	—

15. Considering the irregularity of the coronal structure, we cannot perhaps expect better agreement with any simple law of brightness than is shown by these residuals; and the assumed law, whether it has

any physical significance or not, is, at any rate, a convenient method of expressing the facts. We may now turn to the measures previously given of the 1893 corona,* and see how they accord with this formula. On trial, it is found that a fair accordance can be secured if the constant correction for sky-glare be taken as $2^{-7\cdot8}$ instead of $2^{-6\cdot4}$, and the constants for the four radii measured be

N.	S.	E.	W.	Mean.
−0·1	+0·4	+0·5	+0·1	+0·23

16. With regard to the smaller value for sky-glare, if this depends on the general brightness of the corona itself, we may remark that the 1893 corona was generally fainter, according to the measures, than the 1898 corona, the mean constant for the former being + 0·23, and for the latter + 1·15. The difference is + 0·92, so that the 1898 corona was about twice as bright, and hence twice as bright a sky illumination is not unreasonable.

Table II.—Comparison of Observed Brightness (Photographic) of 1893 Corona with the Law.

Brightness × (distance from Sun's centre)^6 = constant.

(The distances are given in units of the Sun's radius. The brightnesses are expressed by powers of 2; zero representing the Moon's brightness.)

Distance from Sun's centre.	Typical brightness of corona alone.	With "glare" added.	Observed error of formula.			
			N.	S.	E.	W.
1·1	+0·2	+0·2	—	−0·9	—	—
1·2	−0·6	−0·6	−0·1	−0·4	—	—
1·3	−1·2	−1·2	—	−0·1	—	+0·1
1·4	−1·9	−1·9	+0·4	+0·4	−0·3	+0·3
1·5	−2·5	−2·5	+0·2	+0·4	—	+0·5
1·6	−3·0	−2·9	0·0	+0·3	—	—
1·7	−3·6	−3·5	−0·1	+0·4	—	+0·3
1·8	−4·1	−4·0	0·0	+0·2	+0·5	+0·1
1·9	−4·6	−4·4	−0·2	+0·1	—	0·0
2·0	−5·0	−4·8	−0·2	−0·1	—	—
2·1	−5·4	−5·2	−0·2	−0·2	—	−0·3
2·2	−5·8	−5·5	−0·1	−0·2	−0·2	−0·7
2·3	−6·2	−5·8	−0·3	−0·3	—	0·0
2·4	−6·6	−6·1	+0·2	−0·1	—	—
2·5	−7·0	−6·3	+0·1	0·0	—	0·0
2·6	−7·3	−6·5	+0·3	0·0	0·0	+0·1
2·7	−7·6	−6·7	—	+0·1	—	−0·1
2·8	−7·9	−6·8	+0·3	−0·1	—	—
2·9	−8·2	−7·0	—	−0·1	—	+0·1
3·0	−8·5	−7·1	+0·3	−0·1	0·0	+0·1

* 'Roy. Soc. Proc.,' vol. 66, p. 403.

17. The discrepancies are again not large, and some of them may be due to the extrapolation which was necessary for the brighter parts of the corona, the standard squares not having been given a long-enough exposure (as stated in the former paper) to compare with the long exposure of 50 secs. to the corona. Measures on plates with a shorter exposure to the corona will perhaps allow of more accurate results near the sun's limb. Unfortunately no plate is available with an exposure shorter than 5 secs., but measures on this plate, so far as they have gone, indicate a closer accordance with the theoretical formula near the limb. Further measures are, however, required.

18. With the assumed law

$$\text{brightness} = Ar^{-3},$$

where r represents distance from the sun's limb in solar radii, the total brightness of the corona is

$$\int_1^\infty Ar^{-6} \times 2\pi r dr = \tfrac{1}{2}\pi A,$$

the total brightness of the full moon being represented by

$$\int_0^1 2\pi r dr = \pi.$$

Thus the ratio of the total brightness to that of the moon is $\frac{1}{2}$ A. In 1898 the value of A was approximately $2^{1\cdot15} = 2\cdot2$, and thus the whole corona was about equal to the full moon. In 1893 the value of A was $2^{0\cdot23} = 1\cdot2$; and the whole corona was thus about 0·6 of the full moon.

19. But we have omitted the constant illumination of the sky in this integral. If we include a portion of sky extending to distance R from the limb, and B be the value of the constant for "glare," which in 1893 was taken as $2^{-7\cdot8} = 0\cdot0046$, and in 1898 was $2^{-6\cdot4} = 0\cdot012$, then we must add to the above quantities

$$\frac{1}{\pi} B \int_1^R 2\pi r dr = B(R^2 - 1) \text{ full moon.}$$

It is not, however, easy to assign a definite value to R.

20. The integral brightness of the corona was measured in 1893 by the late Mr. James Forbes, jun.,* and found to be 1·1 full moon. We find $[0\cdot6 + B(R^2 - 1)]$ full moon.

If the two quantities be equated, we get

$$B(R^2 - 1) = 0\cdot5$$

or

$$R^2 = 0\cdot5/0\cdot0046$$

$$= 110$$

or

$$R = 10\cdot5.$$

* 'Phil. Trans.,' A, 1896, p. 433.

Thus, if we suppose that Mr. Forbes measured the total light within a circular area 5° in diameter, which seems a fair supposition,* the two measures of total brightness agree.

On the same supposition, the value of $B(R^2 - 1)$ in 1898 would be 1·3 full moon, and the total brightness of the corona would appear as 1·1 + 1·3 = 2·4 full moon.

Summary.

(*a.*) The brightness of the corona of 1898 at a point distant r from the sun's *centre* expressed in solar radii may be approximately represented by the formula

$$\text{brightness} = Ar^{-6} + B,$$

where A and B are constants.

(*b.*) The first term may be considered as corona proper, while B may be taken as representing the constant illumination of the sky, or glare. In 1898 the value of B was $2^{-6\cdot4} = 0\cdot012$ moon, taking the brightness of the moon as 0·02 candle at 1 foot.

(*c.*) The constant A varies with the radius along which measures are made. In 1898 it varied from $2^{0\cdot0}$ moon to $2^{1\cdot9}$ moon, the mean being $2^{1\cdot115}$ moon or 2·2 moon.

(*d.*) The same formula will fairly represent the 1893 corona, the mean value of A being $2^{0\cdot23} = 1\cdot2$, and the value of B $2^{-7\cdot8} = 0\cdot0046$.

(*e.*) The total brightness of the corona depends on the area of sky included. If a circular area 5° in diameter be included, the total brightness of the 1893 corona may be taken as 1·1 full moon, agreeing with the visual measures made, and that of 1898, on the same supposition, would be about 2·4 full moon.

* The dimensions of the box are not given, either here or in the previous paper to which we are referred; but on p. 369 of the 'Philosophical Transactions,' A, 1889, there is a diagram of the box, from which it would appear that the angular aperture was not greater than 12°, judging by outside measurements.

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"The New Star in Perseus.—Preliminary Note." By Sir NORMAN LOCKYER, K.C.B., F.R.S. Received and Read February 28, 1901.

Dr. Copeland was kind enough to inform me by telegram on the afternoon of February 22, of the discovery by Dr. Anderson of a new star in the Milky Way in Perseus on the early morning of that day. It was stated that its position was R.A. $3^h\ 24^m\ 25^s$ and Declination $+43^\circ\ 34'$, its magnitude 2·7, and colour of a bluish-white. Later in the evening this information was corroborated by another telegram from the "Centralstelle" at Kiel.

Owing to cloudy weather, no photographs could be obtained at Kensington until the evening of the 25th. Momentary glimpses of the star on the evening of the 22nd, between the hours of 6 and 7.30 P.M., indicated that the Nova had considerably brightened since the time of its discovery, as it was estimated as a little brighter than a 1st magnitude star; no satisfactory observations of the spectrum could be made. Another glimpse on the early morning (1.30 A.M.) of Monday (25th) showed that the star was still of about the 1st magnitude.

Professor Pickering reports that the Nova was dimmer than an 11th magnitude star on February 19. On the 23rd it was as bright as Capella. The star, therefore, was then at least 10,000 times brighter than it was four days previously, and ranks as the brightest new star recorded since that which appeared in the year 1604.

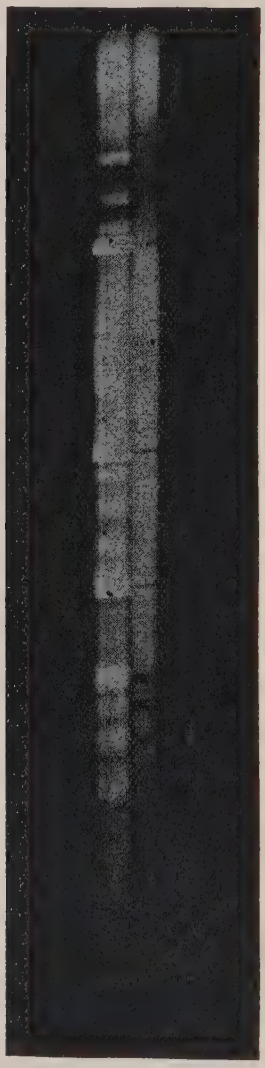
Since the 25th the brightness has diminished slightly, and on the evening of the 27th was estimated between the 1st and 2nd magnitude (1·7). If this reduction of brilliancy continues at the same rate, the new star will evidently be shorter lived than those to which it has most closely approximated in luminous intensity at the maximum, and less time will be available for studying the spectral changes which may be anticipated. I may state that Tycho's Nova (1572) was visible for nearly $1\frac{1}{2}$ years, and Kepler's (1604) for about the same period.

It is interestiug to note that the star was described by Dr. Anderson as being of a bluish-white colour at the time of discovery. Since it has diminished in brightness this has changed, and on the night of February 27, a reddish tinge was observed.

The sky on Monday evening was by no means free from clouds, but ten very satisfactory photographs were secured with the three instruments in regular use for stellar spectra. Edwards's isochromatic plates were used, as it was considered desirable to secure a record of the green part of the spectrum.

Although there has not been time for a complete discussion of these photographs, it may be stated that the spectrum contains numerous dark lines, several of which are associated with bright bands on the

less refrangible side. Further, the spectrum, as a whole, greatly resembles that of Nova Aurigæ.



(A). Spectrum of Nova Persei.
(B). " " α Persei, photographed on the same plate.
Taken with a 30-inch common reflector and a two-prism slit spectroscope.

One of the chief features of the principal bright lines is their great width, amounting to 30 tenth-metres, and each is accompanied by a dark line of considerable breadth on its more refrangible side. A comparison spectrum of γ Orionis, photographed alongside that of the Nova on one

of the plates, indicates that the middle portions of the bright lines are not far from their normal positions; those of the dark ones, however, are displaced by some 15 tenth-metres towards the violet, thus indicating a differential movement of something like 700 miles a second.

Movements more rapid and disturbances more violent than those observed in Nova Aurigæ are therefore indicated; both by the greater displacement of the dark lines relatively to those that are bright and the greater breadth of the bright and dark lines.

The comparison of spectra shows us that we are dealing with two swarms, one of which, the less dense, gives us broad bright lines and is almost at rest with reference to the line of sight; the denser swarm, indicated by the dark lines, is in most rapid movement in the line of sight towards the earth.

An interesting feature of the spectrum is the presence of fine dark lines down the middle of each of the bright lines of hydrogen and calcium; these are most probably reversals, and if this be so, they will be of great service for accurate determination of the wave-lengths of the other bright lines. The dark hydrogen line Hγ, and perhaps Hβ and Hδ, are also possibly reversed.

Eye observations showed among the chief lines a group of four in the green; one probably Hβ, the others near $\lambda\lambda$ 492, 501, and 517; a bright line at or near D, and a brilliant red line probably corresponding to Hα. Each of these was accompanied by a dark broad line on its more refrangible side. Other lines of less brightness were observed both in the green and red.

It at first seemed probable that two of the bright lines in the green ($\lambda\lambda$ 492 and 501) might be due to asterium, while that in the orange was perhaps the helium line D_3. Subsequent investigation, however, suggested as an alternative origin that these lines might be the enhanced lines of iron at λ 4924·1 and 5018·6, which are very nearly in the same positions as the asterium lines. This view was tested by inquiring whether other prominent enhanced lines of iron so strongly visible in the spectrum of α Cygni were present.

A comparison with the spectrum of this star photographed with the same instruments suggested that many lines between F and *h* in the Nova probably correspond with lines in α Cygni. Certainty could not be arrived at in consequence of the great breadth of the lines in the Nova.

Hence, as the Nova bore some resemblance to both Nova Aurigæ and α Cygni, a reference was suggested to the lines recorded in the spectrum of Nova Aurigæ which were observed when the light of that star was on the wane, and when the lines were thinned enough to be easily measurable. I may also add that these observations were made before the work on enhanced lines was undertaken.

The importance of this reference was strengthened by the considera-

tion that with such a tremendous outburst we should expect the original invisible swarm to have been (very rapidly) advanced to a considerable condensation at the locus of impact, and therefore to resemble some "star" which had (slowly) arrived at a position pretty high up on the ascending temperature curve in the ordinary course of evolution on the meteoritic hypothesis.

A comparison of the bright lines recorded by Campbell* and Vogel† in the spectrum of Nova Aurigæ with the strongest lines of α Cygni—a very detailed record of the spectrum of which star has been recently compiled here—shows that there is a close agreement between the two sets of lines. These strong α Cygni lines are almost without exception the representatives of "enhanced" lines of some of the metals, chiefly Fe, Ti, Cr, Ni, Ca, Sr, and Sc. If we exclude the lines of hydrogen from those which were recorded in the spectrum of Nova Aurigæ, there remain forty-four lines for comparison. Thirty of these, or about 70 per cent., agree approximately in position with either strong isolated lines or groups of lines in the spectrum of α Cygni.

It may be assumed that, taking into consideration the broad nature of the Nova lines, if there be any genuine connection between them and the lines of α Cygni, any close groups of separately distinguishable lines in the latter spectrum would be thrown together in the Nova spectrum, and appear as broad bands. A good instance of this appears in Campbell's list. He records a band extending from $\lambda\lambda$ 4534 to 4501. In the spectrum of α Cygni there is a strong line at each of the positions given, and between them there occurs a strong quartet of lines. The former are well enhanced lines of titanium, and the latter of iron. It seems extremely likely, therefore, that the six lines thrown together produce the apparently continuous band observed by Campbell.

If the stage of α Cygni has really been reached, the following considerations come in:—

In the orderly condensation of swarms, according to the meteoritic hypothesis, the earlier stages are—

Ascending temperature. ↑

Cygnian	Dark lines, corresponding chiefly with the enhanced lines of various metals.
Polarian	Dark lines, comprising both arc and enhanced lines of various metals.
Aldebarian	Dark lines, chiefly corresponding to those which appear in the arc spectra of various metals.
Antarian	Mixed bright and dark flutings and dark lines. Bright lines of hydrogen in those stars which are variable.
Nebula	Bright lines.

* 'Ast.-Phys. Jour.,' vol. xi, p. 807, 1892.

† 'Ast.-Phys. Jour.,' vol. xii, p. 912, 1893.

In the case of new stars, after the maximum of luminosity has been reached, however high they ascend, short of the apex of the temperature curve, this order must be reversed, and hence we should expect to find the spectrum varying in accordance with the foregoing sequence, but in the reverse order.

In Nova Coronæ (1866), according to the observations of Sir William Huggins and Dr. Miller, the absorption spectrum was very similar to that of α Orionis, which is a star of the Antarian group, so that the temperature attained was relatively low; this indeed is demonstrated by the fact that at present it shines faintly as an Antarian star, and doubtless did so before the collision. The collision, therefore, probably did not take Nova Coronæ very much above its initial stage of temperature, and when the disturbance was over it simply reverted to its old conditions.

The spectrum of Nova Cygni (1876) was not photographed, and as special attention was given by most observers to the bright lines, there is no satisfactory record of the absorption spectrum.

This now appears as a nebula, and doubtless it was a nebula to begin with, as Nova Coronæ was a star to begin with.

In Nova Aurigæ (1892), as we have seen, the comparison with α Cygni indicates that the Cygnian (a higher) stage was reached, and in the final stages its spectrum corresponded with that of the planetary nebulæ, that is, a stage lower than that reached by Nova Coronæ. The intermediate stages, however, were not observed, possibly because the star was never very brilliant, and partly because of the difficulty of observing closely grouped lines, such as occur in the Polarian and Aldebarian stages when they are rendered broad by such disturbances as those which were obviously present in the Nova.

The observed maximum magnitude in the case of a new star will evidently depend upon the distance and size of the colliding masses, as well as upon the temperature produced by the collision. It is not remarkable, therefore, that there is no apparent relation between the greatest brightness and the temperature indicated by the spectra. Nova Coronæ, with its relatively low temperature, shone for a time as a 2nd magnitude star, while Nova Aurigæ, with a much higher temperature, scarcely surpassed a star of the 5th magnitude.

I now return to Nova Persei. If the idea that in the present Nova the swarm which gives the dark line spectrum resembles α Cygni be confirmed; as its temperature is reduced we may expect it to pass successively through some or all of the stages of temperature represented by stars of the Polarian, Aldebarian, and Antarian groups, enhanced lines being first replaced by arc lines, and then by flutings. Whether it remains at one of these stages or undergoes a further backwardation into a nebula will be a point of the highest interest.

If, like Nova Aurigæ, the present Nova should end as a nebula, it

will furnish a most convincing proof of the fundamental metallic nature of nebulæ.

In conclusion, I wish to express my thanks to Dr. W. J. S. Lockyer and Mr. F. E. Baxandall, of the Solar Physics Observatory, and to Mr. A. Fowler, of the Royal College of Science, who have greatly assisted me in preparing the present note, and who, with the addition of Mr. Butler, of the Solar Physics Observatory, secured the excellent set of photographs and eye observations on the night of the 25th, from which the new knowledge has been derived.

The preparation of the slides I owe to Sapper J. P. Wilkie.

"Further Observations on Nova Persei." By Sir Norman Lockyer, K.C.B., F.R.S. Received and Read March 7, 1901.

[Plate 1.]

Since the preliminary note on this star was communicated to the Royal Society on February 28th, observations have been possible on the nights of February 28th, March 1st, 3rd, and 5th, and twenty-four photographs of the spectrum have been taken with the instruments before detailed.

It may be stated generally that the light is slowly waning. On February 28th the star was only slightly brighter than α Persei. On March 1st it was estimated as about equal to α Persei, *i.e.*, about 2·0 magnitude. When it was again visible on the evening of March 3rd, it was distinctly less bright than β Persei, and its magnitude probably near 2·5; on the 5th its estimated magnitude was 2·7.

The above refers to the visual brightness. A photograph of the region occupied by the Nova on March 3rd showed it to be photographically brighter than α Persei.

General Description of the Spectrum.

The photographs show that the bright hydrogen lines are successively feebler as the ultra-violet is approached, and the whole of the series of hydrogen lines have during the past week become relatively brighter with respect to the remaining lines and the continuous spectrum. The spectrum extends far into the ultra-violet.

Among the changes which have taken place in the visible part of the spectrum, it may be mentioned that while the lines of hydrogen have become relatively brighter during the past week, the remaining lines, with the possible exception of the prominent one at λ 5169, have become distinctly dimmer. There has also been a diminution of the intensity of the continuous spectrum. The line in the yellow, the identity of which has not yet been definitely determined, has gradually decreased in intensity with the diminution of brightness of the star.

In the visible part of the spectrum the bright green-blue F line of hydrogen has become more conspicuous as the neighbouring green lines have become fainter, and the bright C line is intensely brilliant.

From all these causes, which give us blue light on the one hand and red on the other, the star should present to us the precise quality of red which has been observed.

Colour.

At discovery the star was described as bluish-white. No observations on its variation in hue during its brightening were possible, owing to unfavourable weather conditions. The observations during the period of decline have indicated a change to the present colour of a decided claret red. In comparison with this, it is interesting to note that in the case of the Nova which appeared in 1604, Kepler alludes to purple and red tints assumed by the star.

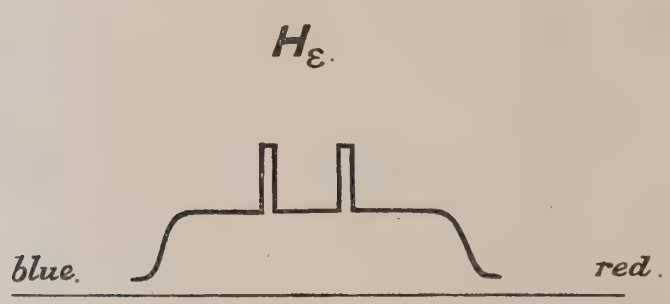
Changes in the Photographic Spectrum.

Between February 25th and March 5th, to take the extreme difference of dates on which photographs were obtained, it has been noted that while some of the dark lines were absent at the later date, either new lines had come in or previously feeble lines had become intensified. There has not yet been time to determine accurately the positions of these lines (see Plate 1).

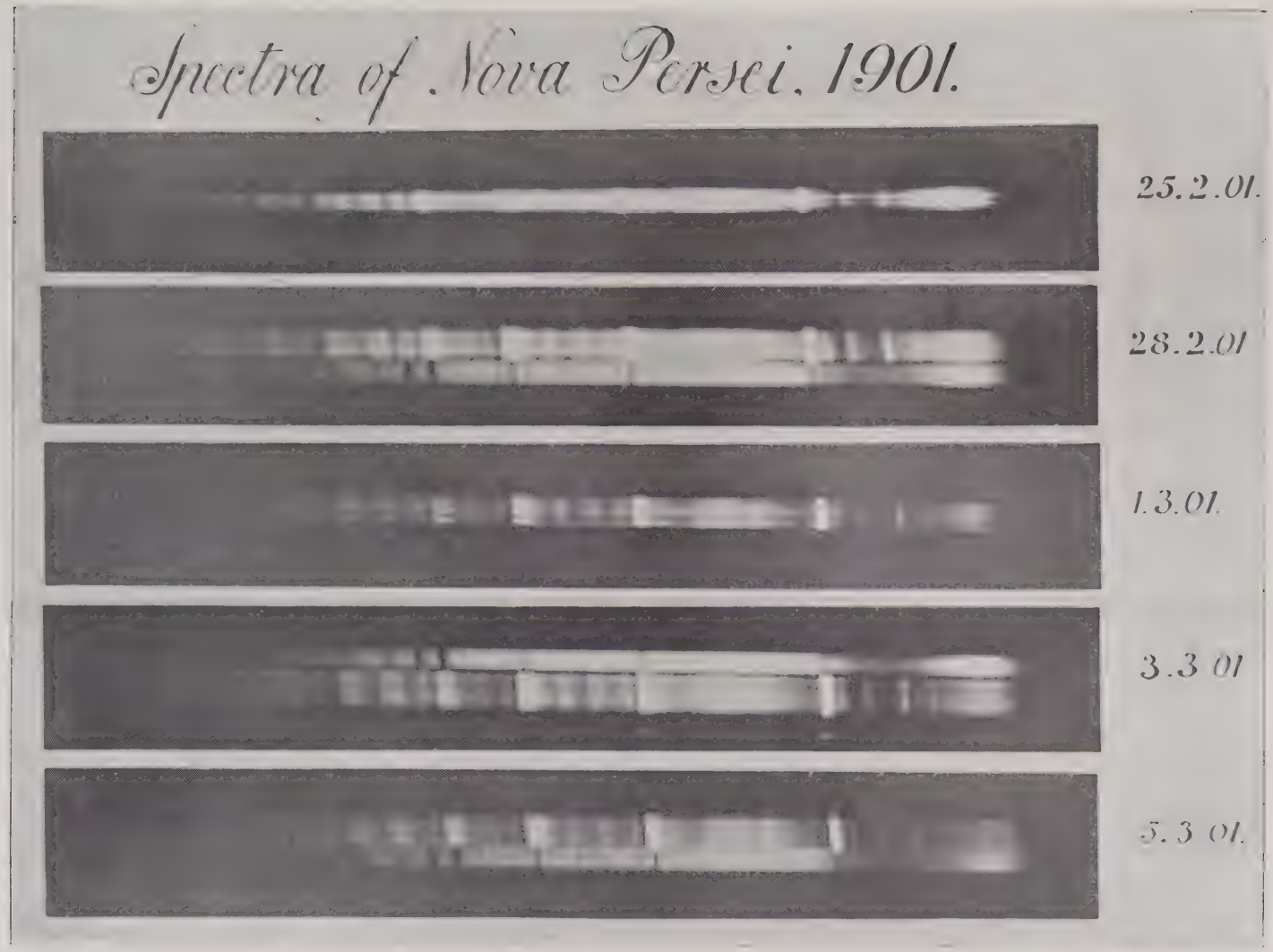
The appearance of the bright lines of hydrogen which I described as being reversed on February 25th, had very materially changed by March 3rd.

In inspecting the dark band representing the bright hydrogen at Hϵ, two darker fine lines are seen nearly coincident in position with the edges of Hϵ in the spectrum of α Persei.

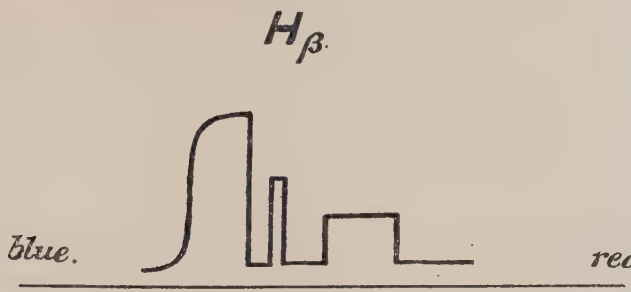
To my eye the light curve is as follows:—



The appearance is different in the case of the F line (Hβ), a light curve of which I also give—



Series of Photographs of the Spectrum of Nova Persei.
Taken with 30-inch reflector and with a slit spectroscope of two prisms.
(Comparison spectrum in each case is that of α Persei.)



No doubt the differences in the appearances are due to the fact that at Hϵ we are dealing with the lines both of hydrogen and calcium.

Rough measurements on the bright line Hβ show that the interval between the centres of the two extreme maxima shown in the light curve corresponds to about 25 tenth-metres. This would give a differential velocity of 960 miles per second between the different sets of hydrogen atoms in the bright-line swarm itself.

It may be then that the appearances described as reversals of the hydrogen lines on February 25th, were but the beginning of the subsequent changes.

The comparisons with stars which have been taken with the slit spectroscope on each evening of observation, indicate that no great change in the velocity of the dark-line component has occurred.

So much, however, cannot be said of the bright lines, in which a change has been observed. In addition to the hydrogen lines the strong lines in the green already ascribed to iron, appear to be double in the photographs most recently obtained.

Comparison with α Cygni.

The view of the apparent similarity between the spectra of Nova Persei and Nova Aurigæ, to which I drew attention in my previous paper, has been strengthened by the comparisons which have since been made.

The bright lines in the spectrum of Nova Persei are so broad, especially in the blue and violet, that accurate determinations of their wave-lengths are difficult to obtain. The lines less refrangible than F, however, besides being more isolated, are narrower than those in the more refrangible part of the spectrum. A direct comparison of these with the lines in the spectrum of a star which is known to contain the enhanced lines of iron, &c., has been considered a better method of arriving at some definite conclusion as to the connection between the Nova lines and the enhanced lines, than that of determining the wave-lengths of the broad lines and comparing the results with the known wave-lengths of the enhanced lines.

The best star for this purpose is α Cygni, but unfortunately no good photograph has been obtained at Kensington of the green portion of the spectrum of that star. The star most nearly approaching α Cygni in relation to enhanced lines is α Canis Majoris, which in the Kensington classification has been placed nearly on a level with the former star, but on the descending side of the temperature curve. In the spectrum of this star the enhanced lines of iron $\lambda\lambda$ 4924·11, 5018·63, $\left\{\begin{matrix}5169{\cdot}07\\5169{\cdot}22\end{matrix}\right.$ and 5316·79 occur as well-marked lines. This spectrum has been directly compared with that of Nova Persei taken with the same instrument, and the fact that all the lines apparently coincide, affords good evidence that the connection is a real one, and that the first four strong Nova lines beyond F on the less refrangible side are the representatives of the enhanced lines of iron. These are the only enhanced lines which occur in that part of the iron spectrum, with the exception of a weak one at λ 5276·17. There is only a trace of this line in the spectra of either the Nova or α Canis Majoris which have been compared. In the spectra of the Nova obtained with lower dispersion, however, a line is distinctly shown in this position, though it is considerably weaker than the four lines previously mentioned.

The absence of the strong lines which are familiar in the arc spectrum, and in the ordinary spark spectrum in this region, is to be ascribed to higher temperature; experiments which are in progress show that under certain conditions, the two lines λ 5018·6 and λ 5169 are by far the strongest lines in the spectrum of iron between λ 500 and D, while that at λ 4924·1 is distinctly stronger than any of the well-known group of four arc lines in which it falls.

The published wave-lengths of the lines of Nova Aurigæ show that the same lines were present in that star. Further investigations of the spectrum of Nova Aurigæ have strengthened the conclusion that most of the lines, after we pass from those of hydrogen, are enhanced lines of a comparatively small number of metals.

When the inquiry is extended into the region more refrangible than Hβ, the evidence in favour of the similarity of the spectra of the two Novæ with that of α Cygni is not so conclusive, because of the greater breadth of the lines (since the spectra have been obtained by the use of prisms) and because of the fact that in this region the enhanced lines of iron frequently occur in groups.

In the region between Hδ and Hγ, however, there is a well marked enhanced line of iron at λ 4233·3 and also two doubles at $\lambda\lambda$ 4173·7, 4179·0, and $\lambda\lambda$ 4296·7, 4303·3, and a comparison of α Cygni with Nova Persei indicates that these fall on broad bright bands of the Nova spectrum.

It is not claimed that all the enhanced lines which appear in the spectrum of α Cygni are represented in that of Nova Aurigæ. There

is, however, a sufficient reason why at a particular stage in the spectrum of such Novæ the enhanced lines of certain substances should predominate. Thus, in γ Cygni, titanium is most strongly represented by enhanced lines; in α Cygni, iron, chromium, and nickel; in β Orionis, silicium and magnesium, and so on. We may thus expect to find the lines of different substances most prominent at different stages in the history of the star.

In the work above referred to I have been assisted as follows:—The new photographs have been taken by Dr. Lockyer and Messrs. Fowler, Baxandall, Shackleton, Butler, Shaw, and Hodgson. The detailed examination of the photographs has been made by Messrs. Fowler and Baxandall. The visual observations have been chiefly made by Messrs. Fowler and Butler. The photographs have been enlarged and the illustrations for this paper prepared by Sapper Wilkie. To all, my best thanks are due.

"On the Enhanced Lines in the Spectrum of the Chromosphere." By Sir Norman Lockyer, K.C.B., F.R.S., and F. E. Baxandall, A.R.C.S. Received March 19,—Read March 28, 1901.

In the recently published account* of the spectroscopic results obtained by members of the expedition from the Yerkes Observatory, during the solar eclipse of May 28th, 1900, although the record of the wave-lengths of the lines photographed on the different eclipse plates is of great value, exception must be taken to the method of assigning origins to the lines. This question is so important just now that it is desirable to deal with it without delay. The only origins which Professor Frost appears to accept are those given by Rowland to any moderately strong solar line which agrees in position, either exactly or very nearly, with an eclipse line. In discussing the eclipse lines he has made specific allusions to the "enhanced" lines of some of the metals, and to their relationship—or non-relationship—to the eclipse lines.

On p. 347 he says, "These plates give no evidence of any relationship between the bright lines and the 'enhanced' lines, or lines distinctly more intense in the spark than in the arc spectrum, although Sir Norman Lockyer has attached much significance to a supposed connection between them. Some of the enhanced lines are present and some are not, or at least were not conspicuous enough for measurement." In the paragraph immediately following, he says, "In case of titanium, for which Lockyer gives 48 enhanced lines within our limits, we may summarise the comparison as follows: 17 lines do

* Frost, 'Ast.-Phys. Journ.,' vol. 12, p. 307, 1900.

not appear as bright on the eclipse plates; one pair is doubtful, the remainder occur as quite strong lines of the ordinary dark line spectrum, and hence would be expected to appear in the reversing layer, as they do."

If a difference of 0·3 tenth-metre be allowed between the wave-length of an eclipse line and that of the possibly corresponding metallic line (and in some cases Professor Frost accepts a difference of 0·35 or more between his adopted wave-length and Rowland's solar wave-length), the seventeen lines above mentioned dwindle down to ten. That leaves, then, thirty-eight out of forty-eight of the enhanced lines, or about 80 per cent., which agree in position within 0·3 tenth-metre with the eclipse lines. Surely this shows as close a relationship between the enhanced lines of titanium and the eclipse lines, as that between the latter and the stronger of the Fraunhofer lines, for it is stated on p. 345, "of 171 of Rowland's lines, 61 per cent. were measured as bright on the plates."

Nowhere has it been contended that the whole set of enhanced lines belonging to any one metal are represented in the spectrum of any one celestial body; what has been stated is that the enhanced lines of some of the metals are, in general, of paramount importance in the spectra of some stars (*e.g.*, α Cygni), specially prominent in others (*e.g.*, γ Cygni, the spectrum of which, with the exception of the absence of helium lines, very closely resembles that of the chromosphere), and are a marked feature of the spectrum of the chromosphere itself.

Professor Frost either has not noticed, or does not point out, that most of the enhanced lines of titanium, as compared with the ordinary lines of that element, are specially prominent, and are amongst the lines of greatest intensity in his list, as shown in the following table. The first two columns of the table contain respectively the wave-lengths and intensities of Rowland's solar lines (in the region covered by the eclipse lines), which have an intensity of 2 or more, and which have been ascribed to Ti only. Double assignations, of which Ti forms one, have been omitted, as it is difficult, if not impossible, to determine what proportion of the intensity of the solar line is due to each element. The third column indicates whether the titanium line at the given wave-length is an enhanced one or not. The fourth gives the wave-lengths, the fifth and sixth the intensities, and the eighth the origins which Professor Frost has adopted for the corresponding eclipse lines, and the seventh the intensities of the lines reduced from the Kensington eclipse photographs. To make them roughly comparable with Professor Frost's, these intensities have been multiplied by ten throughout, as 1 is adopted for the weakest lines in the Kensington photographs, whereas he adopts 10 for lines just visible.

Solar Lines of Intensity 2 or greater, ascribed by Rowland to Ti only.

Solar – Ti lines λ (Rowland).	Int. in sun.	If enhanced line.	Eclipse. Frost. Adopted wave-length.	Frost. Intensity. Max. 500. Prism spectra. "Flash" II.	Frost. Intensity. Max. 500. Prism spectra. Cusp II.	Kensington. Int. Max. 100.	Frost's origin.	Remarks.
4028·50	4	yes	4028·28	35	20	25		Eclipse line undoubtedly due to Ti.
4078·63	3	no	4078·6	15	—	—	Fe, Ti	
4171·21	4	no	4171·30	20	15	—	Ti	
4274·75	2	no	4274·93	75	30	50	Cr	Eclipse line undoubtedly due to Cr.
4285·16	2	no						
4286·17	2	no	4286·0	6				
4288·04	2	no	4287·91	25	25	—	Ti	
4289·24	2	no						
4290·38	2	yes	4290·34	40	20	65	Ti	Line in Kensington photograph probably compounded of Cr 4289·89 and Ti 4290·38
4291·11	3	no	4291·11	12	12	—	Ti	
4291·28	2	no						
4294·20	2	yes	4294·41	70	—	50	Fe	Probably due to Fe 4294·30 + Ti 4294·20, but there is more evidence for Ti than Fe.
4298·83	2	no						
4299·80	2	no						
4300·21	3	yes	4300·36	60	20	50	Mn	Evidence in favour of Mn origin very weak, that for Ti very strong.

				Grating spectra.				
				"Flash" I.	"Flash" II			
4300·73	2	no						
4301·16	2	no						
4302·09	2	yes	4301·96	40	15	—	Ti	
4306·08	4	no						
4313·03	3	yes	4312·99	40	25	20	Ti	
4315·14	3	yes	4315·28	40	30	45	Ti, Fe	Eclipse line probably Ti 4315·14 + Fe 4315·26.
4338·08	4	yes	4337·99	25	20	50	Ti, Sr?	Evidence for Sr negligible.
4341·53	2	yes	—	—	—	—	—	Probably masked by Hγ.
4344·45	2	yes	4344·42	50	25	30	Ti	
4367·84	2	yes	4367·64	25	15	25	Fe	Probably due to Ti 4367·84 + Fe 4367·68, but evidence for Ti much better than that for Fe.
4394·22	2	no						
4395·20	3	yes	4395·27	50	50	70	Ti	
4417·88	3	yes	4417·80	18	30	45	Ti	
4427·27	2	no	4427·4	12	12	30	Ti, Fe	Possibly due to Fe 4427·44 + Ti 4427·27, but evidence for Fe greater than that for Ti.
4443·98	5	yes	4444·0	40	35	70	Ti	
4449·31	2	no						
4450·65	2	yes	4450·6	18	20	50	Ti?	
4453·49	2	no						
4464·62	2	yes	4464·6	6	12	25	Ti?	
4468·66	5	yes	4468·8	50	30	60	Ti	
4501·45	5	yes	4501·44	35	35	70	Ti	
4512·91	3	no						
4518·20	3	no	4518·0	—	5			
4522·97	2	no	4522·7	15	25	40	Ti	Eclipse line undoubtedly due, in the main, to enhanced Fe 4522·69.

Solar Lines of Intensity 2 or greater, ascribed by Rowland to Ti only—*continued*.

Solar — Ti lines λ (Rowland).	Int. in sun.	If enhanced line.	Eclipse.					Remarks.
			Frost.			Kensington.	Frost's origin.	
			Adopted wave-length.	Intensity. Max. 500. Prism spectra.		Int. Max. 100.		
				"Flash" II.	Cusp II.			
4527·49	3	no						
4533·42	4	no						
4534·95	4	no						
4535·74	3	no	—	—	—	} 20		λ of eclipse line 4535·9.
4536·09	2	no	—	—	—			
4536·22	2	no						
4544·86	3	no	—	—	—	30		
4548·94	2	no						
4552·63	2	no						
4555·66	3	no						
4563·94	4	yes	4563·94	30	40	75		
4572·16	6	yes	4572·16	45	45	70		
4617·45	3	no						
4623·28	2	no						

In the above list of solar-titanium lines there are thirty-three which are not "enhanced" in the spark spectrum. It will be seen that twenty-three of these—or 70 per cent.—have no corresponding line (within 0·3 tenth-metre) in Professor Frost's record of eclipse lines. Of the nine eclipse lines in the table which do agree approximately in position with unenhanced titanium lines, two are with certainty due to other metals, and in another case there is more evidence for an iron origin than one of titanium. These are indicated in the column for remarks. The remainder are nearly all lines of insignificant intensity.

Of the twenty "enhanced" lines of titanium which occur in the list, nineteen have corresponding lines in Professor Frost's eclipse spectra, the remaining one being also possibly represented, but it falls so near the strong Hγ line that it might be easily masked. Not only are they represented in the eclipse spectra, but in nearly every case the corresponding eclipse line is a prominent one, as will be gathered at once from a glance at the tabular list given.

Professor Frost summarily dismisses the significance of the enhanced lines of titanium in the eclipse spectra, because "most of them occur as quite strong lines in the ordinary dark line spectrum, and hence would be expected to appear in the reversing layer, as they do." But if he would expect one line of a certain solar intensity, he should expect all lines due to the same element which are of an equal solar intensity, to appear in the eclipse spectra. Yet another glance at the foregoing table will show that many of the titanium lines strongly represented in the eclipse spectra are of the lowest intensity in the Fraunhofer spectrum, and that if lines of a certain solar intensity be considered, those that are enhanced lines appear in the eclipse spectra, whereas the unenhanced ones do not.

In this comparison no account has been taken of the relative intensities of the lines in the titanium spectrum itself. Hasselberg has published* a lengthy list of titanium arc lines, and in the region covered by the eclipse spectra records about 250. To compare all these with the eclipse lines would take too much time and space, nor is it necessary. To show the difference in behaviour in the eclipse spectra of the enhanced and the strongest arc lines, two separate lists of titanium lines have been made. The first, which follows immediately, contains all the enhanced lines which occur in Hasselberg's arc list, and the intensities of Professor Frost's and the Kensington eclipse lines which correspond within 0·3 tenth-metre are also given.

* 'Kongl. Svenska Vetenskaps Akad. Handl.,' vol. 28, No. 1, 1895.

Enhanced Lines of Titanium recorded by Hasselberg in Arc Spectrum, and their behaviour in Eclipse Spectra.

Enhanced lines in Hasselberg's Ti arc spectrum.		Eclipse.					Remarks.
		Frost.			Kensington.	Frost's origin.	
		Adopted wave-length.	Intensity max. 500. Prism spectra.		Int. max. 100.		
λ.	Int. Max. 8.		"Flash" II.	Cusp II.			
4025·26	2					—	Undoubtedly due to Ti.
4028·48	3	4028·28	35	20	25		
4053·96	3	4053·9	12	—	30	Fe, Ti	Probably due to enhanced Ti 4053·98 + enhanced V 4053·80.
4055·18	5	4054·98	40	?	—	Fe	Evidence for Ti stronger than that for Fe.
4161·67	2	4161·81	80	5	35		
4163·80	5	4163·86	50	12	40	Ti, Cr	Evidence for Cr weak.
4172·04	4	4172·15	80	15	35	Ti, Fe	
4173·66	3	4173·75	50	?	45	—	Probably due to enhanced Fe 4173·52 + enhanced Ti 4173·70.
4174·20	2						
4290·37	5	4290·34	40	20	65	Ti	Line in Kensington photograph probably compounded of Cr 4289·89 and Ti 4290·38.
4294·28	6	4294·41	70	—	50	Fe	Probably due to Fe 4294·30 + Ti 4294·20. More evidence for Ti than Fe.
4300·19	6	4300·36	60	20	50	Mn	Evidence for Ti origin far outweighs that for Mn.
4302·08	5	4301·96	40	15	—	Ti	
4313·01	6	4312·99	40	25	20	Ti	
4315·15	4	4315·28	40	30	45	Ti Fe	Probably due to Ti 4315·14 + Fe 4315·26.

4316·96	4	4316·79	12	6			
4321·12	3	4321·06	60	50	50	Sc	Probably due to enhanced Ti 4321·20 + Sc 4320·91.
4330·85	3	4330·71	30	?	25		
4338·05	6	4337·99	25	20	50	Ti, Sr?	Evidence for Sr negligible.
4341·51	3	—	—	—	—	—	Probably masked by Hγ.
4344·47	3	4344·42	50	25	30	Ti	
4350·99	2						
4367·81	3	4367·64	25	15	25	Fe	Probably due to Ti 4367·84 + Fe 4367·68. Better evidence for Ti than Fe.
4374·97	2	4374·8	60	30	70	—	Probably due to enhanced Ti 4374·90 + Sc 4374·63.
4387·00	2						
			"Flash" I	"Flash" II			
4395·17	7	4395·20	50	50	70	Ti	
4395·99	3						
4399·92	5	4399·9	7	—	55	Ti, Cr	
		4400·3	25	30		Sc	
4417·88	5	4417·80	18	30	45	Ti	
4464·60	3	4464·6	6	12	25	Ti?	
4468·65	6	4468·8	50	30	60	Ti	
4488·47	3						
4501·43	6	4501·44	35	35	70	Ti	
4534·15	5	4534·2	40	60	75	Ti, Co	Probably due solely to Ti.
4549·79	6	4549·9	40	55	75	Ti, Co	Probably due to enhanced Fe 4549·64 + enhanced Ti 4549·81.
4563·94	5	4563·94	30	40	75	Ti	
4572·15	6	4572·16	45	45	70	Ti	
4590·11	4	4590·1	12	10	30		

Reference to the above table will show that the "arc" intensities of the enhanced lines vary from 2 to 7 (maximum intensity adopted is 8), and that nearly throughout Frost records corresponding eclipse lines, the majority of the latter being quite prominent.

The second list consists of the very strongest arc lines (intensity 7 and 8) which are not enhanced in the spark spectrum. Here again the intensities of the corresponding eclipse lines, if any, are quoted.

Strongest Arc Lines of Titanium, and their relation to Eclipse Lines.

Titanium arc. (Hasselberg.)		Eclipse.				
		Frost.			Kensington.	Frost's origin.
			Intensity. Max. 500.			
λ.	Int. Max. 8.	Adopted wave-length.	Prism spectra.		Int. Max. 100.	
			"Flash" II.	Cusp II.		
4186·27	7	4186·3	—	5		
4286·15	7	4286·0	6			
4287·55	7	—	—	—	10	
4289·23	7					
4295·91	7	4295·98	7	15		Cr, Ti, Ni.
4298·82	7					
4300·73	7					
4301·23	7					
4306·07	8					
4314·95	7					
4318·83	7	4319·02	20	12		Ca, Mn?
			Grating spectra.			
			"Flash" I.	"Flash" II.		
4427·28	8	4427·4	12	12	30	Ti, Fe.
4457·59	7	4457·8	—	5	—	Ti, V, Zr Mn.
4518·18	7	4518·0	—	5	10	
4533·42	7					
4534·97	7					
4544·83	7	—	—	—	30	
4548·93	7					
4552·62	7					
4617·41	7					

Here, it will be observed, there are only seven out of the twenty strongest titanium arc lines which have possibly corresponding lines in Frost's eclipse spectra. To three of these eclipse lines he assigns no origin; to the others he gives compound origins, three of them involving titanium. In no case is the corresponding eclipse line as

Solar Lines of Intensity 2 or greater, ascribed by Rowland to Fe only. (λ 4500 to λ 4600.)

Solar – Fe lines λ (Rowland).	Int. in sun.	Int. in arc spectrum (K. & R).	If enhanced line.	Eclipse.					Remarks.
				Frost.			Kensington.	Frost's origin.	
				Adopted wave-length.	Intensity. Max. 500. Grating spectra. "Flash" I.	"Flash" II	Int. Max. 100.		
4508·46	4	1	yes	4508·4	7	15	50	Fe?	
4517·70	3	4	no	4518·0	—	5			
4520·49	3	1	yes	4520·4	8	17	30	Fe?	
4525·31	5	6	no	4525·0	—	7	—	Fe	
4528·80	8	10	no	4528·6	—	5	30	Fe	Strongest line in this region of the iron spectrum.
4531·33	5	8	no						
4531·80	2	4	no						
4548·02	3	8	no						
4549·64	2	4	yes	4549·9	40	55	75	Ti, Co	Probably due to enhanced Fe 4549·64 + enhanced Ti 4549·81.
4550·94	2	—	no						
4560·27	2	2	no						
4574·90	2	4	no						
4584·02	4	2	yes	—	25	35	70	Fe	
4587·31	2	4	no						
4592·84	4	8	no						
4595·54	2	4	no						
4596·25	2	2	no						
4598·30	3	6	no						

strong as the majority of those which are the representatives of the enhanced lines.

In the case of iron, all the well-enhanced lines are represented in the eclipse spectra, but they are not of quite the same prominence as the titanium enhanced lines. They are, so far as their intrinsic intensities in the iron arc spectrum are concerned, quite insignificant lines as compared with the majority of other iron lines, but their importance lies in the fact that they are a class of lines of special behaviour, being relatively stronger in the spark spectrum than in the arc. In the eclipse spectra they are undoubtedly represented by stronger lines than are the *great majority* of unenhanced iron lines, however strong the latter may be in the iron arc spectrum itself.

Owing to the great number of iron lines in the solar spectrum, a comparison similar to that given for titanium over the whole region covered by the eclipse lines would necessitate the compilation of a very lengthy list. But whatever evidence there is either one way or another should be revealed by a comparison over a limited region, so it is proposed to take that between λ 4500 and λ 4600, since the proportion of enhanced to unenhanced iron lines is there greatest, and therefore a better opportunity is afforded of a fair comparison of the behaviour of the two classes of lines. The table given on p. 187 is arranged in exactly the same way as in the case of titanium, with the exception that there is an additional column showing the intensities in the arc spectrum, as recorded by Kayser and Runge.

It will be seen that the unenhanced lines are here also unrepresented in the eclipse spectra, with the possible exception of three, which are recorded as very weak lines in one of Professor Frost's spectra, but are missing from the other. All the enhanced lines, however, although they have the weakest arc intensities, appear in each of the eclipse spectra, and have abnormal intensities compared with those corresponding to the unenhanced lines. It must be pointed out that only four of the nine enhanced iron lines in the part of the spectrum considered appear in the above list, because they are the only ones which are given in Rowland's origins for solar lines. At least four out of the remaining five—those at $\lambda\lambda$ 4515·51, 4522·69, 4556·10, 4576·51, probably correspond to the solar lines 4515·51, 4522·69 (or possibly 4522·80), 4556·06, and 4576·51, to which Rowland has assigned no origin. The outstanding line at λ 4541·40 is doubtfully present in the solar spectrum. The first three of these five have corresponding lines in the eclipse record; the other two have not. In the Kensington reductions of eclipse spectra there are, however, lines agreeing (within 0·3 tenth-metre) with every one of the enhanced lines mentioned.

"Further Observations on Nova Persei, No. 2." By Sir NORMAN LOCKYER, K.C.B., F.R.S. Received and Read March 28, 1901.

In continuation of two previous papers, I now bring the observations of the Nova made at Kensington to midnight of March 25. Since the last paper* of March 7th, estimates of the magnitude of the Nova have been made on ten evenings, visual observations of the spectrum on eight evenings, and photographs of the spectrum on four evenings up to the evening of the 25th.

In consequence of the greater faintness of the Nova, the 6-inch prismatic camera has not been utilised, but the 10-inch refractor to which it is attached has been used for eye observations of the spectrum with a McClean spectroscope.

With the 30-inch reflector four photographs have been secured on the evenings of the 6th, 10th, 24th, and 25th by Dr. Lockyer, and with the 9-inch prismatic reflector seven photographs on the nights of 10th, 21st, and 25th by Messrs. Butler and Hodgson.

Change of Brightness.

Since March 5th the magnitude of the star has been gradually decreasing, but between the nights of the 24th and 25th the light of

* *Supra*, p. 142.

the Nova decreased very suddenly, dropping from 4·2 to 5·5 in twenty-four hours, and becoming only just visible as a naked-eye star.

The following gives a summary of the eye estimates made by (1) Dr. Lockyer, (2) Mr. Fowler, and (3) Mr. Butler:—

	(1.)	(2.)	(3.)
March 5.....	2·7	2·7	—
6.....	2·9	—	—
9.....	—	3·5	3·5
10.....	3·7	—	—
11.....	—	—	<4·0
12.....	—	3·8	—
21.....	—	4·0	4·2
22.....	—	—	—
23.....	4·2	4·2	4·5
24.....	4·2	4·2	4·5
25.....	5·5	5·5	5·5

Colour.

The colour of the Nova has undergone some distinct changes since the observation on March 5th last, when it was shining with a clarety-red hue. On the 9th and 10th it was observed to be much redder, due probably to the great development of the red C line of hydrogen.

On the 23rd and 24th, the star was noted as yellowish-red, while on the 25th (after the sudden drop in magnitude) it was very red, with, perhaps, a yellow tinge.

The Visual Spectrum.

Since March 5th the spectrum from C to F has become very much fainter, the bright lines of hydrogen being relatively more prominent than they were before; indeed, C and F throughout this period have been the most conspicuous lines, especially the former, while the bright lines λλ 5169, 5018, and 4924, and the line in the yellow near D, were the most prominent of the others.

All these lines have been gradually becoming weaker, but there is an indication that λ 5018* has been brightening relatively to λ 5169.

Accompanying the great diminution in the light of the Nova observed on the evening of the 25th, the spectrum was found to have undergone a great change: the continuous spectrum had practically disappeared, and a line near D (probably helium, D_3) became more distinct. The other lines were hardly visible.

* The line near this wave-length in later observations is probably the chief nebular line 5007, which accounts for the apparent brightening of 5018.

The Photographic Spectrum.

On March 6th the photographs were very similar to those obtained in the earlier stages, the only apparent difference being in the relative intensity of the bright hydrogen lines as opposed to those having other origins, most of which have been shown to be probably due to iron and calcium. The hydrogen lines have sensibly brightened, while the others have become much feebler.

The photograph of March 10th shows a further dimming of the bright lines other than those of hydrogen.

On March 25th, when the next good photograph was taken, the spectrum had undergone great modifications. The hydrogen lines are still very bright, though they do not show the structure which they did in the photographs taken between February 25th and March 10th. The bright lines other than those of hydrogen, which are seen in the earlier photographs, have now disappeared, and other lines become visible. The continuous spectrum has also greatly diminished.

Approximate determinations of the wave-length of these new lines have been made by Mr. Baxandall by comparison with lines of known wave-length in the spectra of α and ϵ Persei photographed with the same instrument. They are as follows :—

λ	
3870.	Broad, and merging into Hζ (3889).
4367.	Weak.
4472.	Not very strong. Probably helium (λ 4471·6).
4565.	Weak.
4650.	Very strong broad line. Possibly the 465 line of the bright-line stars and the belt stars of Orion.
4690.	Moderately strong. Possibly new hydrogen (λ 4687·88) seen in bright-line stars and some Orion stars.
471.	Weak. Probably helium (λ 4713).

The hydrogen lines in the spectra are Hζ, Hϵ, Hδ, Hγ, and Hβ.

The lines at λ 3870 and 4650 are perhaps identical with those observed by von Gothard* in the spectrum of Nova Aurigæ after it had become nebular, but associated with these lines in his record is the chief nebular line at 5007, no trace of which is yet visible in the photographs of the spectrum of Nova Persei. On the other hand, Hβ, which is the brightest line in the present spectrum of Nova Persei, does not appear at all in von Gothard's spectrum of Nova Aurigæ.

Characteristics of the Hydrogen Lines.

In my former paper I referred to the structure of the broad bright lines of hydrogen. A more detailed examination of the lines as photo-

* 'Ast.-Phys. Jour.,' vol. 12, 1893, p. 51.

graphed on several evenings shows that this structure has been undergoing changes.

The annexed figure (fig. 1) gives light curves showing the variation

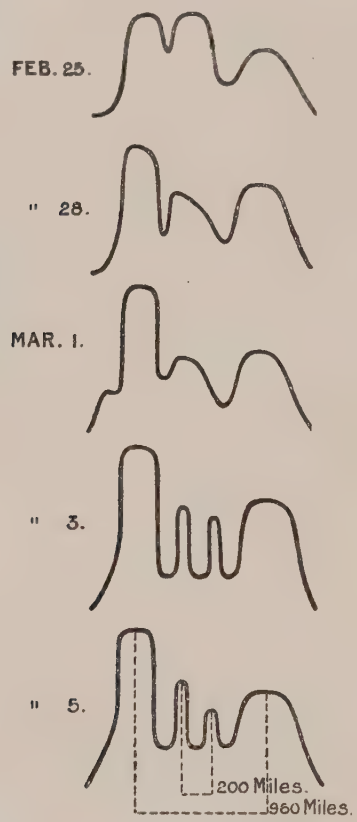


FIG. 1.—Light curve of Hβ (6-inch objective prism).

in the loci of intensity of the line Hβ, as photographed with the 6-inch prismatic camera. These curves were plotted by Messrs. Baxandall and Shaw independently of each other, and I have satisfied myself of their accuracy. It will be seen that on February 25th there were three points of maximum luminosity, the two maxima on the blue side being of equal intensity, and greater than the third on the red side. By March 1 the centre one had been greatly reduced in intensity, and on the 3rd it had been broken up into two portions, thus making four distinct maxima.

Rough measures made on the relative positions of these points of maxima show that the difference of velocity indicated between the two external maxima is nearly 1,000 miles per second, while that between

the two inner maxima is 200 per second. We thus have indications of possible rotations or spiral movements of two distinct sets of particles travelling with velocities of 500 and 100 miles per second.

A similar examination of the F and G lines of hydrogen in the photographs obtained with the 30-inch reflector has also been made by Dr. Lockyer, and the light curves for the G line are here illustrated (fig. 2). In this longer series the most important point comes out that

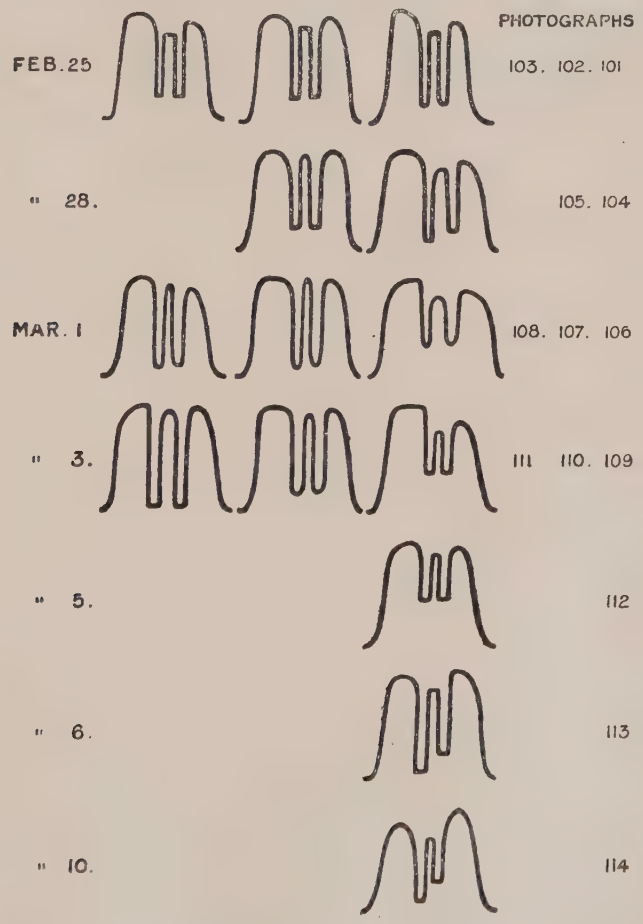


FIG. 2.—Light curve of Hγ (30-inch reflector).

the maximum intensity changes from the more to the less refrangible side of the bright hydrogen line.

The small dispersion given by the 30-inch prevents some of the details recorded by Messrs. Baxandall and Shaw from being seen.

So far as the observations have gone, they strongly support, in my

opinion, the view I put forward in 1877 that "new stars" are produced by the clash of meteor-swarms; and they have suggested some further tests of its validity.

We may hope since observations were made at Harvard and Potsdam very near the epoch of maximum brilliancy, that a subsequent complete discussion of the results obtained will very largely increase our knowledge. The interesting question arises whether we may not regard the changes in spectrum as indicating that the very violent intrusion of the denser swarm has been followed by its dissipation, and that its passage has produced movements in the sparser swarm which may eventuate in a subsequent condensation.

My best thanks are due to those I have named for assistance in this inquiry.

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MONTHLY NOTICES

OF THE

ROYAL ASTRONOMICAL SOCIETY.

APPENDIX TO VOL. LXI.

[*From Proceedings of the Royal Society, Vol. LXVIII.*]

With indication of the original pagination.

No. 3.

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"The Solar Activity 1833–1900." By WILLIAM J. S. LOCKYER, M.A., Ph.D., F.R.A.S., Assistant Director, Solar Physics Observatory, Kensington. Communicated by Sir NORMAN LOCKYER, K.C.B., F.R.S. Received April 29,—Read May 23, 1901.

Introduction.

A close examination of the curves representing the varying amount of spotted area on the Sun's surface, shows that no two successive cycles are alike either in form or area. The individuality of the cycles seems, on further inspection, to be repeated after a certain period of time, and this peculiarity, coupled with a like variation in the curves representing the variations of the magnetic elements, and with suspected cycles of change in various terrestrial phenomena, suggested a new investigation of the whole subject.

The object of this communication is to place before the Royal Society the first results which an examination of the various records has furnished.

Dr. Rudolf Wolf,* of Zürich, from a study of the sunspot observations made up to the end of 1875, drew attention to the facts, to use

* 'Mem. R. Astron. Soc.,' vol. 43, p. 200.

his own words, that "la fréquence des taches solaires persiste à changer périodiquement depuis leur découverte en 1610; que la longueur moyenne de la période est de $11\frac{1}{9}$ ans, et que cette même période satisfait aux changements de la variation magnétique, et même de la réquence des aurores boréales."

Dr. Wolf was careful to point out that it was only the *mean length* of the solar period that covered a period of $11\frac{1}{9}$ years, and that the real length of any one period might differ from this value by as much as two years. The form in which he stated this result* was

$$T = 11{\cdot}111 \pm 2{,}030 \text{ (als Schwankung)} \pm 0{,}307 \text{ (als Unsicherheit)};$$

where T represented the length of the period, ± 2,030 the variation from the mean value, and ± 0,307 the probable error of the determination.

His attention was also drawn to the fact that the times of maxima did not occur a constant number of years after a preceding minimum, and he was led to determine the *mean* time of occurrence of the maximum after the preceding minimum and of the minimum after the preceding maximum, giving the *mean* intervals as 4·5 and 6·5 years respectively.

Further, he at first concluded that the total spotted area for each period was nearly constant, but, as he later remarks,† this view could not be held, as these quantities not only varied but indicated "eine bestimmte Gesetz-mässigkeit." The length of the period of this variation he gave as about 178 years, which covered practically sixteen ordinary sunspot periods. ("11,1111 × 16 = 177,7777.")

Somewhat later Dr. Wolf was led to suggest a shorter period of 55·5 years, which comprises about five ordinary eleven-year periods.

In a recent paper‡ Professor Simon Newcomb has published the results of his investigation of the irregularities in the successive sunspot periods, using as a basis Dr. Wolf's numbers up to the end of 1872, and the spot areas as derived from the Greenwich reduction of the solar photographs taken daily at Greenwich, Dehra Dun, and Mauritius.

The final conclusion at which he arrives is summed up in the following paragraph :—

"Underlying the periodic variations of spot-activity there is a uniform cycle unchanging from time to time and determining the general mean of the activity."

Professor Newcomb mentions, however, no length of period for this cycle, but speaking of its origin he remarks, "whether the cause of this cycle is to be sought in something external to the Sun or within

* 'Astron. Mittheil.,' Wolf, 187 ; p. 40.

† 'Astron. Mittheil.,' 1876, p. 47 *et seq.*

‡ 'The Astro-Physical Journal,' vol. 13, No. 1, 1901, p. 1.

it; whether, in fact, it is in the nature of a cycle of variations within the Sun, we have, at present, no way of deciding."

In the investigations on periods of solar activity most workers have relied simply on Wolf's numbers, which are given by him back to the year 1749. Any one acquainted with these knows that from the time *systematic* observations of the Sun's surface were commenced by Hofrath Schwabe (1833), these numbers agree very closely with the actual facts; but before that date, the numbers are based, not on facts alone (which were not very numerous), but on a system of "meaning,"* suggested by the results of the observations from 1833 to 1876.

Although then Dr. Wolf was able to present us with a curve dealing with the spotted area from 1749, it was decided for the present communication to limit the discussion to those relative numbers which are based on the actual systematic observations since 1833. This necessarily restricted the investigation to a comparatively short number of years, namely, sixty-six (1833–1899), but it was thought that any variations detected, if greater than any which might be justifiably considered errors of observation, would be based on sound facts, and not on uncertain data.

The important magnetic results obtained from a discussion of the Greenwich Observations by Mr. William Ellis,† placed at my disposal a most valuable check on any variation that might be obtained from the sunspot curves, Mr. Ellis having shown that the curves for the magnetic elements are in almost exact accord with those of the sunspots obtained by Dr. Wolf. In this connection Mr. Ellis writes‡:

"Considering that the irregularities in the length of the sunspot period so entirely synchronise with similar irregularities in the magnetic period, and also that the elevation or depression of the maximum points of the sunspot curve is accompanied by similar elevations and depressions in the two magnetic curves, it would seem, in the face of such evidence, that the supposition that such agreement is probably only accidental coincidence can scarcely be maintained, and there would appear to be no escape from the conclusion that such close correspondence, both in period and activity, indicates a more or less direct relation between the two phenomena, or otherwise the existence of some common cause producing both. The sharp rise from minimum epoch to maximum epoch, and the more gradual fall from maximum epoch to minimum epoch, may be pointed out as characteristic of all three curves."

* For Wolf's method of "meaning" see 'Astronomische Mittheilungen,' von Rudolf Wolf, Zürich, 1876, p. 39 *et seq.*

† 'Roy. Soc. Proc.,' vol. 63, p. 64.

‡ *Ibid.*, p. 70.

The Sunspot and Magnetic Epochs employed.

As this paper deals mainly with the times of minima and maxima of both the sunspot and magnetic curves, it was necessary to utilise the results obtained from curves which had been "smoothed," as the original curves are of a subsidiary oscillatory character, especially at maximum.

The sunspot curves just referred to are reproduced in fig. 1. They are so arranged in order of date that each individual curve can be examined separately. The times of succeeding *minima* are arranged vertically under each other, so that any variation as regards acceleration or retardation of the following maxima, and any inequality in the length of the period minimum to minimum can be seen at a glance.

Up to the sunspot maximum of 1870·6 Dr. Wolf has published* the dates of these epochs, and these are utilised here. The more recent epochs have been brought together by Mr. Ellis,† and these complete the data available up to the last epoch, namely, the maximum of 1894·0.

Each of these epochs is indicated in fig. 1 by a short arrow with the corresponding dates. The magnetic epochs here used are those published by Mr. Ellis in the paper just mentioned, and obtained from curves smoothed similarly to those of the sunspot curves. Unfortunately the observations he discussed only commenced in the beginning of 1841, so that comparisons cannot be made previously to this date.

The smoothed curves obtained by Mr. Ellis are not here reproduced, but they will be found in his valuable paper‡ published in 1880.

The Sunspot Curves. Minimum to Maximum.

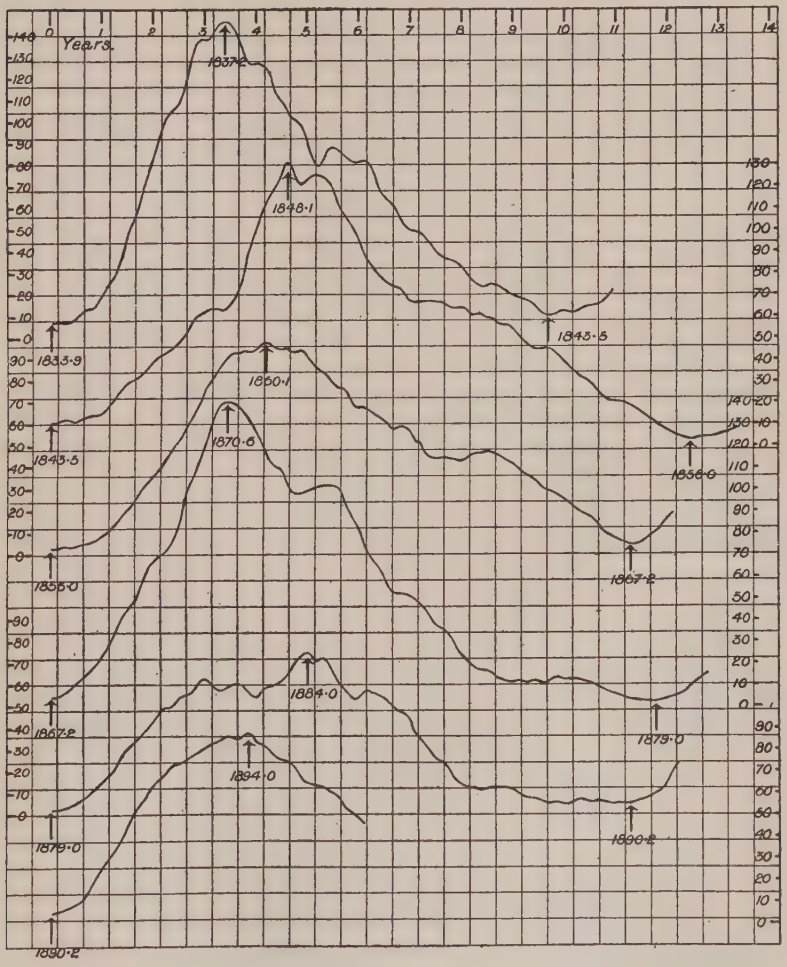
In the following table are brought together the dates of the epochs of maxima and minima:—

Sunspot epochs (Wolf).		Maximum *minus* minimum years.
Minimum.	Maximum.	
(1) 1833·9	1837·2	3·3
(2) 1843·5	1848·1	4·6
(3) 1856·0	1860·1	4·1
(4) 1867·2	1870·6	3·4
(5) 1879·0	1884·0	5·0
(6) 1890·2	1894·0	3·8
		Mean 4·03

* 'Mem. R. Astron. Soc.,' vol. 43, p 202.
† 'Roy. Soc. Proc.,' vol. 63, p. 67.
‡ 'Phil. Trans.,' 1880, Part II, Plate 22.

If these figures in the last column be utilised as ordinates and the time element as abscissæ, the curve in fig. 2 (curve B) is produced. The peculiarity of this curve is that we have a very rapid rise to a maximum in 1843, and slow fall to the minimum in 1867. This is followed

Fig. 1.

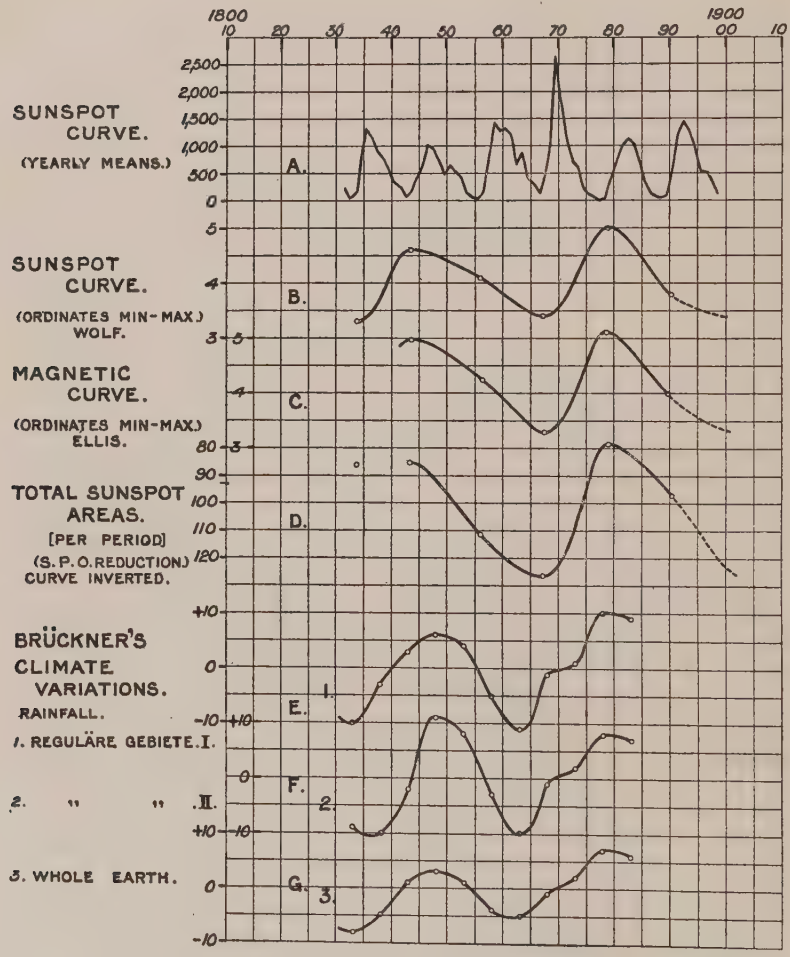


by a similar rapid rise to the next maximum in 1879 and a gradual fall as far as observations at present indicate.

The curve thus indicates that there is some law at work which introduces a secular variation by retarding the sunspot maxima in relation to the preceding minima.

The period of this retardation can be deduced by taking the interval between the times of maxima or minima of this secular variation curve. By considering the minima, *i.e.*, from 1833·9 to 1867·2, we have a period of 33·3 years, and if we take the maxima

FIG. 2.



at 1843·5 and 1879·0 we obtain 35·5 years. The mean of these two values gives a period of 34·4 years.

The Magnetic Curves. Minimum to Maximum.

Mr. Ellis's values for the dates of the magnetic epochs were investigated in exactly the same way as the sunspot epochs were examined.

It may be again mentioned that as the observations he reduced only begin in the year 1841, no comparison can be made with the epochs of 1833·9 and 1837·2.

Forming the table of maximum *minus* minimum as before and adding in the last column the values of maximum *minus* minimum of the sunspot curves from the previous table for the sake of comparison, we have as follows :—

Magnetic epochs (Ellis).		Maximum *minus* minimum.	
Minimum.	Maximum.	Magnetic.	Sunspots.
(1) —	—	—	3·3
(2) 1843·60	1848·55	4·95	4·6
(3) 1856·15	1860·40	4·25	4·1
(4) 1867·55	1870·85	3·30	3·4
(5) 1878·85	1883·90	5·05	5·0
(6) 1889·75	1893·75	4·00	3·8

The nearly complete parallelism of the numbers in the last two columns indicates their strict accord with each other.

The curve showing this magnetic variation is given in fig. 2 (curve C), and it is practically a counterpart of curve B.

The value for the length of the period, as gathered from the interval between the two maxima of this curve at 1843·60 and 1878·85, is 35·25 years, which does not differ very much from the value deduced from the maxima of the corresponding sunspot curve, namely, 35·5 years.

Sunspot and Magnetic Curves Combined. Minimum to Maximum.

By combining the values of the intervals (minimum to maximum) from both the sunspot and magnetic curves, their mean values can be determined as shown in the last column of the following table, the general mean for the whole period being added below :—

From minimum occurring about	Mean of sunspot and magnetic intervals in years.
(1) 1833	3·3
(2) 1843	4·77
(3) 1856	4·17
(4) 1867	3·35
(5) 1879	5·25
(6) 1890	3·90
	Mean .. 4·12

Since these numbers cover more than a complete cycle, they may be combined so that mean values for the intervals minimum—maximum may be obtained for those epochs when the intervals have their largest, intermediate, and smallest values. Thus in the years 1843 and 1879 the maxima followed the minima in 4·77 and 5·25 years respectively, the mean interval thus being 4·91 years. For the intermediate stage (combining (3) and (6)) a value of 4·03 years is found, while for the minimum interval combining (1) and (4) this value 3·32 years.

The actual epoch of maximum relative to the preceding minimum oscillates about the mean value, its greatest amplitude being in the mean 0·8 *year.*

The Total Sunspot Areas. Minimum to Minimum.

The great divergence in the amount of spotted area during consecutive eleven-year cycles suggested that perhaps this periodical retardation of the maxima with respect to the each preceding minimum might be accompanied by variations following the same law. It was observed that when a maximum occurred comparatively soon after a minimum, the tendency of the whole spotted area for that sunspot period was to be increased.

I have been permitted for this inquiry to utilise the values which have quite recently been obtained at the Solar Physics Observatory from a new reduction of the curve representing the solar spotted area, and these values, representing the total spotted area in millionths of the Sun's visible hemisphere from minimum to minimum, are given in the last column of the following table :—

Sunspot period from		Total spotted area.
From minimum	to minimum.	
1833·9	1843·5	86 003
1843·5	1856·0	85 201
1856·0	1867·2	111 514
1867·2	1879·0	126 188
1879·0	1890·2	78 353
1890·2	1901· +	96 734 +

The figures in the last column show a similar but inverted sequence to those in the previous tables. Thus from minimum 1867·2 to the following maximum 1870·6 we have a short interval of time; the spotted area for that period is greatest. If the above values in the last column be graphically shown, and the curve inverted, we have a remarkable similarity (fig. 2, Curve D) to the two curves B and C

previously described. Special attention is called to the slow fall from 1843 to the minimum at 1867·2, and the rapid rise to 1879·0.

It may be remarked that the value for the total spotted area for the period 1833·9 to 1843·5, the earliest value in point of time dealt with, is not quite in harmony with the other values. It is probable that although at this period the time of maximum and minimum could be accurately determined, the values may be too small owing to the fact that Schwabe's observations were not made at that period quite on a uniform plan. Mr. Warren de la Rue and Professor Balfour Stewart* on this point wrote :—

"By the commencement of 1832 Schwabe had matured his system to such an extent as to give, no doubt with considerable precision, the shape and area of each group; although it was not until the commencement of 1840 that he finally fixed upon the system of delineation, which he henceforth pursued up to the time when he discontinued his observations."

The above suggestion seems to be borne out by the reduction of sunspot photographs secured at the Wilna Observatory, where it was found that the maximum of 1870 was of about the same order as that of 1836. The Report of the Wilna Observatory for the year 1871 refers to this point in the following terms† :—

"The curve traced from our observations about the last maximum period of spots (1870) is one and a-half times as high as that of the three most recent periods, *i.e.*, the total sum of the areas of the spots about the maximum period of 1870 was one and a-half times larger than during the last thirty-six years. This marked difference obliged us to enter upon a double verification of our calculations, but we did not discover any appreciable errors."

With reference to the value given in the last line of the last column of the table, although this is probably very near the truth, it is yet impossible to state the date of the present minimum (1901·2 probably). All the areas recorded since the minimum of 1890 and up to the beginning of 1900 have been employed; this value is, however, only slightly below the real one, so that a + sign has been printed against it.

If, therefore, these two facts be kept in mind, it will be seen that the inverted total sunspot-area curve can be considered practically an exact counterpart of the other two curves.

The Total Area of the Magnetic Curves. From Minimum to Minimum.

The remarkable similarity between the magnetic and sunspot curves, especially in the later years when such observations are naturally more

* 'Report of the Committee on Solar Physics, 1882.' Appendix B, p. 77.

† *Ibid.*, Appendix D, p. 154.

accurate, made it unnecessary to discuss the variation (as shown in the case of the sunspot areas) regarding the total areas of the curves from minimum to minimum. This variation seems to be more pronounced in the curve representing the horizontal force than in that representing declination.

Length of the Period of Variation thus determined.

In summing up the values obtained for the length of the secular period of variation under discussion, we form the following table :—

	Maximum to maximum. Years.	Minimum to minimum. Years.
Sunspot curve	35·5	33·3
Magnetic „	35·25	—
Total spotted area for period	35·5	—
Means	35·41	33·3
Combined mean	34·89	

The observations thus lead to the conclusion that *underlying the ordinary sunspot period of about eleven years there is another cycle of greater length, namely, about thirty-five years.*

This cycle not only alters the time of occurrence of the maxima in relation to the preceding minima, but causes changes in the total spotted area of the sun from one eleven-year period to another.

The Variation in the Length of the Interval Minimum to Minimum.

Having found a definite variation in the length of the interval minimum to maximum, the curves show a further variation when the interval—minimum to minimum—was considered. An attempt was therefore made to see if any law could be traced, but the inquiry only led to a negative result.

The following table contains the values for the periods—minimum to minimum—and the differences from the mean, for both the sunspot and magnetic curves individually and combined. It will be seen that the alternation of signs in the columns showing the sunspot differences is not corroborated by the magnetic differences, but when the combined values are used this oscillation for consecutive periods is still *en evidence* :—

Minimum beginning in the year	Sunspots.		Magnetics.		Combination.	
	Minimum to minimum.	Differences from mean.	Minimum to minimum.	Differences from mean.	Minimum to minimum.	Differences from mean.
	Years.	Years.	Years.	Years.	Years.	Years.
1833	9·6	−1·7	..	..	9·6	−1·7
1843	12·5	+1·2	12·55	+1·0	12·52	+1·32
1856	11·2	−0·1	11·40	−0·14	11·30	+0·10
1867	11·8	+0·5	11·30	−0·24	11·55	+0·35
1879	11·2	−0·1	10·90	−0·64	11·05	−0·15
1890						
Means..	11·3	—	11·54	—	11·20	—

Although there is a suspected variation in the length of both the magnetic and sunspot periods (reckoning from minimum to minimum), which increases and decreases in *alternate* eleven-year periods from a mean value, the observations do not extend over a sufficient interval of time to allow a more definite conclusion to be drawn.

Relation of the Sunspot Curve to the Light Curve of η Aquilæ.

It is generally conceded that the spots on the surface of the Sun are the result of greater activity in the circulation in the solar atmosphere, and therefore indicate greater heat and, therefore, light. This being so, the curve representing the spotted area may be regarded as a light curve of the Sun.

The Sun may thus be considered a variable star (1) the light of which (reckoning from minimum to minimum) is variable, with a mean value of about 11·1 years; (2) the epoch of maximum does not occur a constant number of years after the preceding minimum, but varies regularly, the cycle of variations covering about 35 years.

It is interesting therefore to inquire whether there be any other known star or stars which exhibit variations similar in kind to those given above.

In the year 1896 I undertook the investigation of all the observations, whether published or not, of the variable star η Aquilæ * which had been made between the years 1840 to 1894, numbering in all 12,000.

For the present inquiry the light curve of this star is of great interest, as its chief peculiarities are similar to those I have indicated in connection with the sunspot curve.

Not only are the more rapid rise to maximum and slow fall to

* 'Resultate aus den Beobachtungen des veränderlichen Sternes η Aquilæ,' Inaugural-Dissertation, Universit. Göttingen, 1897 (Dulau and Co., London).

minimum distinct features of the curve, but the periods (reckoning from minimum) vary slightly in length in the course of many *mean* periods. More important still, the time of occurrence of the maximum in relation to the preceding minimum varies to a comparatively *large* extent in the course of *few* mean periods. The facts arranged in tabular form sum up the information with regard both to the sunspot curve and that of η Aquilæ.

To facilitate the comparison, the different intervals of time converted into fractions and multiples of the sunspot (Q) and η Aquilæ (P) periods are given in separate columns.

		Light curve of			
		Sun.		η Aquilæ.	
Minimum to minimum.	Mean value	Years. 11·20	= Q	$7^d\ 4^h\ 14^m\ 4$	= P
	Period of variation	Unknown	?	—	2400 P
	Maximum variation from mean	± >1·4	± >0·12 Q	$\pm 3^h$	0·017 P
Minimum to maximum.	Mean value	4·12 (about)	0·37 Q	$2^d\ 5$	0·31 P
	Period of variation	34·8 „	3·10 Q	—	400 P
	Maximum variation from mean	±0·8 „	±0·07 Q	$\pm 5^h$	±0·03 P

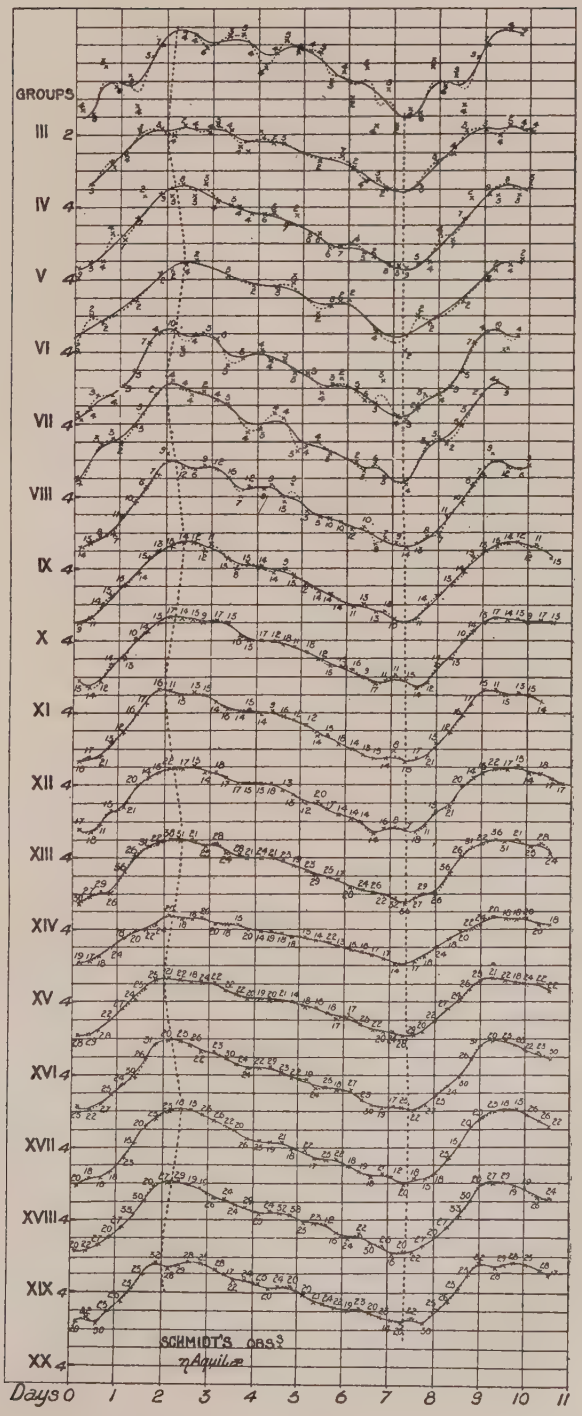
Fig. 3 is a reproduction of a set of light curves of the star η Aquilæ, in which the dotted line and the two vertical wavy and oblique dotted lines passing through the points of maxima and minima indicate the variations of the times of maxima and minima.

The curve for each group is the result of a combination of the observations made over a period equal in length to 100 mean periods (mean period = $172^h{\cdot}2344$) of the star. This whole set of curves is the result of a discussion which I made of all the observations of η Aquilæ made by one observer, Herr Julius Schmidt.

Other Cycles of about Thirty-five Years.

Having found that, in addition to the well-known eleven-year period of sunspot frequency, there is another cycle which extends over about thirty-five years, and which is indicated clearly, as has been shown, both by the changes in the times of the occurrence of the epochs of maxima and in the variations in area included in consecutive eleven-year periods of both sunspot and magnetic curves, it is only natural to suppose that this long-period variation is the effect of a cycle of disturbances in the Sun's atmosphere itself.

FIG. 3.


GROUPS
III
IV
V
VI
VII
VIII
IX
X
XI
XII
XIII
XIV
XV
XVI
XVII
XVIII
XIX
XX
SCHMIDT'S OBS.S
η Aquil.æ
Days 0 1 2 3 4 5 6 7 8 9 10 11

Such a cycle, if of sufficient intensity, should cause a variation from the normal circulation of the Earth's atmosphere, and should be indicated in all meteorological and like phenomena.

It is not intended to go into any detail as regards such terrestrial variations, but it may be noted that much important work has been done on the investigation of changes in climates by Professor Eduard Brückner,* who expended immense labour during many years in the promotion of the inquiry. Professor Brückner did not restrict his discussion to observations made over a small area or for a short interval of time, but utilised those made in nearly every part of the civilised world, and extending as far back in point of time as possible. Further, he did not restrict himself to the discussion of the observations of one or two meteorological phenomena, but examined critically all likely sources from which such changes as he expected could be detected. Thus he sought variations in the observations of the height of the waters in inland seas, lakes, and rivers; in the observations of rainfall, pressure, and temperature; in the movements of glaciers; in the frequency of cold winters; growth of vines, &c.

The result of the whole of the investigation led him to the conclusion that there is a *periodical variation in the climates over the whole earth, the mean length of this period being* $34{\cdot}8 \pm 0{\cdot}7$ *years.*

It may be of interest to remark, that so convinced was Professor Brückner of the undoubted climate variations that he deduced, and so certain was he that such variations could only be caused by an external influence, that he investigated Wolf's sunspot numbers to see whether such a cycle was indicated.

Misled by the long period of variation of sunspots of fifty-five years as suggested by Wolf, he was led to conclude that his climate variation was independent of the frequency of sunspots. He sums up his conclusion in the following words† :—

"Die Klimaschwankungen vollziehen sich unabhängig von den Schwankungen der Sonnenflecken-Häufigkeit; eine 55-jährige Periode der Witterung, wie sie der letzteren entsprechen würde, ist in unseren Zusammenstellungen nicht zu erkennen."

Nevertheless, he was led to make the bold suggestion, that such a variation as he sought must really exist in the Sun, but might possibly be independent of sunspots. He finally concluded that the climate variations are the first symptom of a long period variation in the Sun, which probably will be discovered later.

In the light of the present communication Professor Brückner's conclusions are of great interest, because not only does the length of

* 'Geographische Abhandlungen Wien,' Band 4, Heft 2, p. 155, 1890. "Klima-Schwankungen seit 1700 nebst Bemerkungen über die Klimaschwankungen der Diluvialzeit."

† 'Klimaschwankungen,' Brückner, p. 242.

the period, but the critical epochs of his cycle, completely harmonise with those found in the present discussion of the sunspot and magnetic curves.

To illustrate more fully this connection, and to take only one case, namely, rainfall, the three rainfall curves* are reproduced in fig. 2 (curves E, F, G).

E and F represent the secular variations for what Professor Brückner calls "Reguläre Gebiete I und II,"† while curve E is the mean for the whole set of observations he has employed, and represents the secular variation of rainfall over the whole earth as far as can be determined.

The comparison of these curves with those representing the sunspot and magnetic results given above them, shows that when the epoch of maximum spotted area (curve B) follows late after the preceding epoch of minimum (1843, 1878), or when the spotted area from minimum to minimum is least (curve D), the long-period rainfall curve is at its maximum or we have a wet cycle.

When on the other hand the maximum (curve B) follows soon after the preceding minimum (1867), and the spotted area for this cycle is at a maximum (curve D), the rainfall curve is at a minimum or a dry cycle is in progress.

It may also be observed that in a detailed investigation of the movements of glaciers, Professor Ed. Richter finds a cycle of thirty-five years. In his 'History of the Variations of Alpine Glaciers,'‡ he sums up his results as follows:—"Die Gletschervorstösse wiederholen sich in Perioden, deren Länge zwischen 20 und 45 Jahren schwankt, und im Mittel der drei letzten Jahrhunderte genau 35 Jahre betrug."

Further he pointed out that the variations agreed generally with Brückner's climate variations, the glacier movement being accelerated during the wet and cool periods.

Another very interesting investigation to which reference must be made is that which we owe to Mr. Charles Egeson, who published his researches§ in solar and terrestrial meteorology just a few months before the appearence of Professor Brückner's volume. Mr. Egeson not only finds a secular period of about thirty-three to thirty-four years in the occurrence of rainfall, thunderstorms, and westerly winds in the month of April for Sydney, but the epochs of maxima of the two latter harmonise well with the epochs of the thirty-five yearly period deduced in the present paper for sunspots.

Thus he finds that the yearly numbers of days of thunderstorm

* Brückner, *ibid.*, p. 171.

† Brückner, *ibid.*, p. 170.

‡ 'Zeit. d. Deuts.-Oesterr. Alpen-Vereins,' 1891, Band 12.

§ Egeson's 'Weather System of Sunspot Causality.' Sydney, 1889.

attain their maxima values in 1839 and 1873, and those of the westerly winds in April in 1837 and 1869. As the secular variations of the sunspots have their maxima in 1837·2 and 1870·8, the agreement is in close accord.

There seems little doubt that, during the interval of time covered by the present investigation, the meteorological phenomena, number of auroræ, and magnetic storms, show secular variations of a period of about thirty-five years, the epochs of which harmonise with those of the secular variation of sunspots.

As we are now approaching another maximum of sunspots which should correspond with that of 1870·8, it will be interesting to observe whether all the solar, meteorological, and magnetic phenomena of that period will be repeated.

Conclusion.

1. There is an *alternate* increase and decrease in the length of a sunspot period reckoning from minimum to minimum.

2. The epoch of maximum varies *regularly* with respect to the preceding minimum.

The amplitude of this variation about the mean position is about ± 0·8 year.

The cycle of this variation is about thirty-five years.

3. The total spotted area included between any two consecutive minima varies regularly.

The cycle of this variation is about thirty-five years.

4. There is no indication of the fifty-five-year period as suggested by Dr. Wolf.

5. The climate variations indicated by Professor Brückner are generally in accordance with the thirty-five-year period.

6. The frequency of auroræ and magnetic storms since 1833 show indications of a secular period of thirty-five years.

"Further Observations on Nova Persei. No. 3." By Sir NORMAN LOCKYER, K.C.B., F.R.S. Received May 17,—Read June 20, 1901.

In the last paper* I gave an account of the observations of the Nova made at Kensington between March 5 and March 25 inclusive. The observations are now brought up to midnight of May 7. Between March 25 and the latter date, estimates of the magnitude of the Nova have been made on thirty-three evenings, visual observations of the spectrum on twenty-five evenings, and photographs of the spectrum on six evenings.

The 10-inch refractor with a McClean spectroscope has generally been used for eye observations. The 6-inch prismatic camera has not been available for photographing the spectrum owing to the faintness of the Nova, but photographs have been secured by Dr. Lockyer with the 30-inch reflector on the nights of March 27, April 1 and 12, and by Mr. Fowler on March 26 and April 4. With the 9-inch prismatic reflector the spectrum was photographed by Mr. Hodgson on March 30, April 1 and 4.

Change of Brightness.

Since March 25 the magnitude of the Nova has been undergoing further periodic variations, and although observations have not been made on every night since that date, owing to unfavourable weather, yet sufficient data have been gathered to enable a general idea of the light changes to be obtained, and the few gaps can be filled up later by other observers who experienced clearer skies on these occasions.

The following table is a continuation of the observations for magnitude. Columns (1), (2), and (3) denote the observations made by Dr. Lockyer, Mr. Fowler, and Mr. Butler respectively, and Column (4) includes other estimates made by Mr. Baxandall and Mr. Shaw. The numbers in brackets represent the Greenwich mean time at which the observations (against which they are printed) were made, and refer to the evening hours (P.M.), except where otherwise stated.

Magnitudes of Nova Persei.

	(1)	(2)	(3)	(4)
March 26	4·2 (10.30)	4·2 (10.30)	—	—
„ 27	3·9	4·2	—	4·2 F.E.B.
„ 28	—	5·3	5·3	<5·0 H.S.
„ 30	—	—	4·2	4·2 H.S.
„ 31	4·3	4·3	—	—
April 1	4·4	—	4·4	—
„ 4	4·3 (7.0)	4·4	4·5	—

* Page 230 [37], *suprà*.

Magnitudes of Nova Persei—*continued.*

		(1)	(2)	(3)	(4)	
April	5	4·8 (10. 0)	4·5	—	—	
„	6	5·5 (8. 30)	—	—	—	
„	7	6·0 (7. 30)	5·5	—	—	
„	8	4·2 (11. 0)	—	—	—	
„	9	4·7 (11. 30)	4·5	5·0	4·8	F.E.B.
„	10	5·7 (8. 45)	—	5·5	—	
„	11	5·8	—	5·6 or 7	—	
„	12	5·2 (8. 45) 4·9 (9. 40)	—	5·3	5·0	F.E.B.
„	13	4·6 (11. 30)	—	4·3 (8. 0)	—	
„	14	5·4 (9. 30)	—	5·5	—	
„	15	6·0 or fainter (8. 0) 5·8 or 9 (10. 30)	—	6·0	—	
„	16	5·5 (11. 0)	—	—	—	
„	17	5·2 (8. 30)	—	5·1 (8. 30)	—	
„	18	4·2 (9. 0)	4·2	4·2	4·3	H.S.
„	19	5·2 (8. 0)	—	—	—	
„	20	5·9 or 6·0 (8. 30)	<5·5 (8. 25)	5·6 (8. 30)	—	
„	21	6·1 (9. 0)	—	6·0 or 1 (9. 0)	—	
„	22	5·7 (9. 0)	—	—	—	
„	24	<5·5 (8. 30)	—	—	—	
„	25	5·7 or 8 (8. 15)	5·7	5·6 (9. 0)	—	
„	26	5·6 (9. 0)	5·5 (9. 0)	5·5 (9. 0)	—	
„	27	4·4 (9. 15)	—	4·5 (8. 0)	4·4	H.S.
„	30	<5·6 (9. 15)	5·8 (9. 40)	—	—	
May	3	5·7 (9. 0)	—	—	—	
„	4	6·0 (2. 15 A.M.)	5·8	5·8	—	
„	5	—	—	5·6	—	

It is interesting to note that the length of the period of variability, reckoning from maximum to maximum, began after March 27 to increase from *three* days to *four* days.

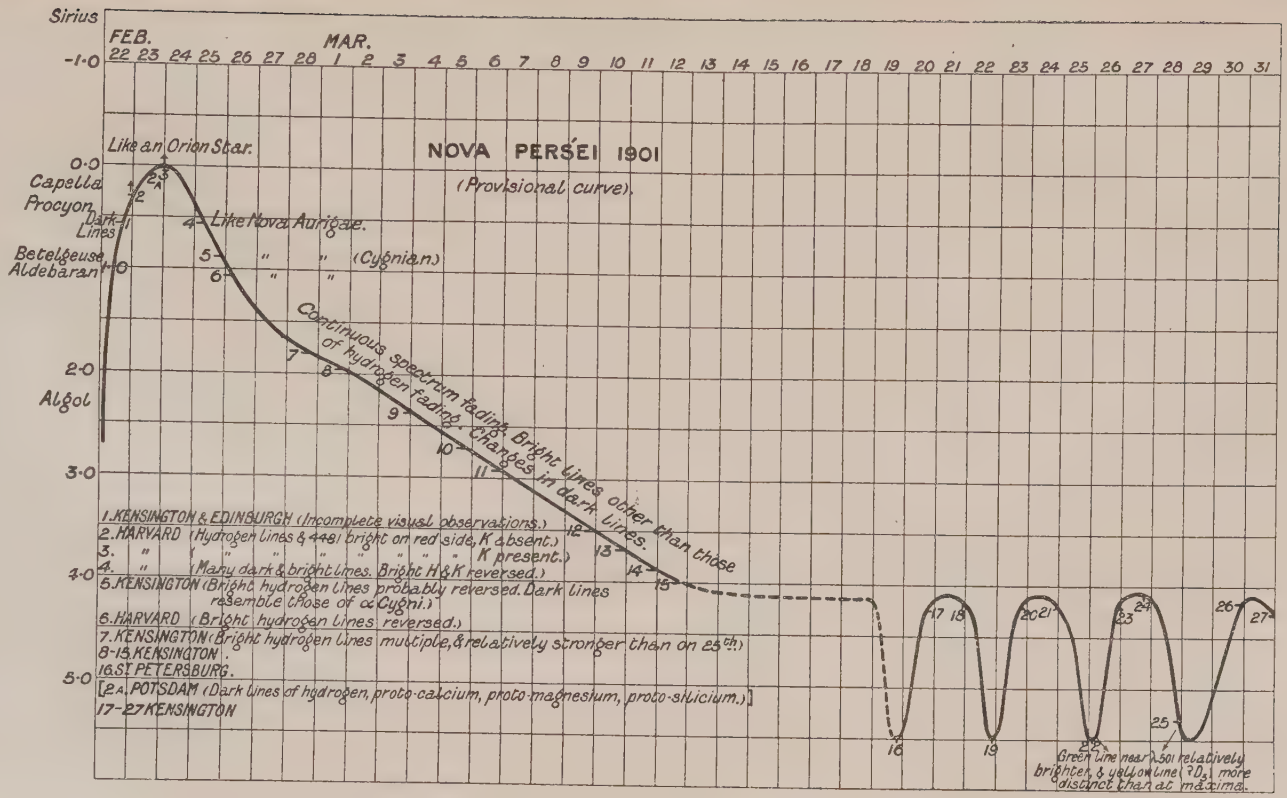
The two following maxima, after that of April 8, occurred on the 13th and 18th, so that the period became still more lengthened, namely, to about *five* days. Further observations up to May 5 seem to indicate that the five-day period is shortening.

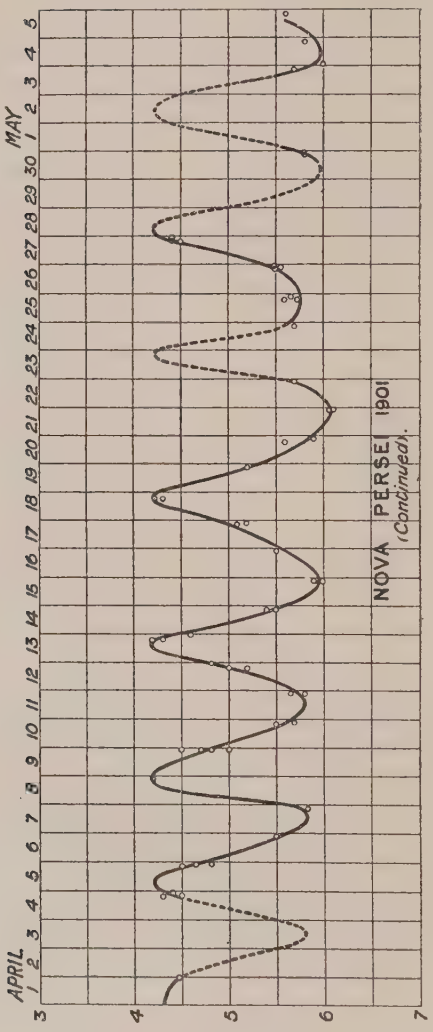
Another interesting observed fact was that the light of the Nova at the minimum on the 25th was more intense than at the preceding minimum on the 21st, the estimated difference of magnitude at these times being about 4-tenths of a magnitude. Unfortunately the increasing twilight and the unfavourable position of the Nova make it very difficult now to determine the magnitudes correctly.

The two plates accompanying this paper illustrate graphically the various fluctuations of the light of the Nova from February 22, when it had not quite attained its maximum brilliancy, to May 5.

The curve is drawn to satisfy as far as possible all the observations made at Kensington. The dotted portions represent the possible light-curve for those times when no estimates for magnitude could be secured.

In the plates the abscissæ represent the time element and the ordinates that of magnitude.


Sirius
FEB.
MAR.
22 23 24 25 26 27 28 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
-1·0
0·0
1·0
2·0
3·0
4·0
5·0
Capella
Procyon
Betelgeuse
Aldebaran
Algol
Dark Lines
NOVA PERSEI 1901
(Provisional curve).
Like an Orion Star.
4 Like Nova Aurigae.
5 " " (Cygnian)
6 " "
Continuous spectrum fading. Bright lines other than those of hydrogen fading. Changes in dark lines.
1. KENSINGTON & EDINBURGH (Incomplete visual observations.)
2. HARVARD (Hydrogen lines & 4481 bright on red side, K absent.)
3. " " " " " " " K present.)
4. " (Many dark & bright lines. Bright H & K reversed.)
5. KENSINGTON (Bright hydrogen lines probably reversed. Dark lines resemble those of α Cygni.)
6. HARVARD (Bright hydrogen lines reversed.)
7. KENSINGTON (Bright hydrogen lines multiple, & relatively stronger than on 28th.)
8-15. KENSINGTON.
16. ST PETERSBURG.
[24. POTSDAM (Dark lines of hydrogen, proto-calcium, proto-magnesium, proto-silicium.)]
17-27. KENSINGTON
Green line near λ501 relatively brighter, & yellow line (D3) more distinct than at maxima.



Colour.

In the first part of the period covered by the later observations, the colour of the Nova has been generally described as yellowish-red, red with a yellow tinge, and yellow with a reddish tinge. Since April 25 the colour has been perhaps more red than formerly, and sometimes noted as very red.

It is interesting to remark that the colour varies periodically with the change in magnitude. At maximum it is of a distinct yellowish-red hue, but at or near minimum the yellowish tinge disappears and the Nova appears very red.

The Visual Spectrum.

In the continued observations the C and F lines of hydrogen have always been recorded as "conspicuous," other prominent lines being near λ 447, λ 465, and λ 501 (the last named being sometimes as bright as F or even brighter), and a line in the yellow which recent measures show to be D_3.

The strong lines in the green at λλ 4924, 5019, 5169, and 5317, which occurred in the earlier photographs, and which were ascribed to iron, are either absent from the later photographs or appear only as very weak lines.

It has been noted that the lines 447, 501, and D_3 appear to vary with the magnitude of the star, becoming relatively more prominent towards a minimum.

The continuous spectrum has been described throughout as "weak" or "very weak."

On the evening of April 25, Messrs. Fowler and Butler made comparisons of the Nova spectrum with the spectra of hydrogen, helium, and that furnished by an air spark between poles of iron and zinc. For this purpose a Hilger two-prism star spectroscope was used with the 10-inch refractor. The hydrogen line F and the helium line D_3 were found to be sensibly coincident with Nova lines. The middle of the strong green line, previously mentioned as λ 501, practically coincided with the nitrogen line 5005·7, and therefore there is little doubt that it is identical with the chief nebular line λ 5007·6. This line was also compared with the asterium line at λ 5015·7, but was found to be decidedly non-coincident with it, though of sufficient breadth to nearly reach it.

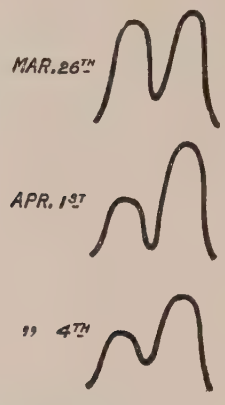
Photographic Spectrum.

In so far as the number and positions of the lines are concerned, the few photographs available for discussion were obtained in the early part of the period dealt with in the present paper (March 26 to May 7), and show a spectrum very similar to that of March 25, which was described in detail in the last paper. The chief lines shown in the photographs are Hβ, Hγ, Hδ, Hε, and Hξ, together with 4471 and 4650.

Characteristics of Hβ.

In continuation of the series of light curves of Hβ reproduced in the last paper, I give those plotted by Mr. Baxandall from the later photographs.

It will be seen that the line Hβ still shows two maxima of intensity. As recorded in the previous paper, the less refrangible component gave



LIGHT CURVE OF H_β
(30-inch reflector).

indications of becoming brighter than the more refrangible member. These further photographs indicate that by April 4 the less refrangible had become twice as intense.

HARRISON AND SONS, Printers in Ordinary to His Majesty, St. Martin's Lane.

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No. 4.

CONTENTS.

Sir David Gill, The spectrum of η Argus . . . . . page [66]

"The Spectrum of η Argus." By Sir DAVID GILL, K.C.B., LLD., F.R.S., H.M. Astronomer at the Cape. Received May 24,—Read June 6, 1901.

[PLATE 2.]

The star η Argus, as is well known, was for a short time almost the brightest star in the heavens. Between 1677 and 1870 its light fluctuated between magnitude 0 and 6·8, and, since the latter date has gradually faded from $6\frac{3}{4}$ to $7\frac{3}{4}$—its magnitude at the present day.

Soon after the McClean telescope was mounted, and by way of testing its performance, a plate was taken, with the object-glass prism of $8\frac{1}{4}^{\circ}$ refracting angle in front of the object glass, of the area of the sky surrounding η Argus.

As this plate showed that η Argus had a very remarkable bright-line spectrum, an attempt was made to obtain a spectrograph with the slit spectroscope, together with a comparison spectrum. Within the past few weeks I have been engaged in measuring some of these experimental spectrograms—a work that other occupations had until now prevented me from undertaking.

As the reductions of the measures show that the spectrum of η Argus closely resembles that of the Nova Aurigæ, it seems to be of considerable interest, in view of the appearance of Anderson's new star in Perseus, to publish the present results, although in many respects they are not so complete as might otherwise be desirable. Thus I have no doubt that, by sacrificing the definition near Hγ and by a longer focal setting and longer exposure, one could get a considerable extension of the spectrum in both directions with the objective prism, and, with the slit-spectroscope, obtain a good determination of the velocity of the star in the line of sight by a much shorter exposure and with direct comparison of the brightest star-line with Hβ. These further points may, however, remain for future investigation.

The plate taken with the slit spectroscope is shown in fig. 1 (Plate 2). It was exposed as follows:—

1899.	April 14	Exposure	165 minutes.
	,, 15	,,	10 ,,
	,, 16	,,	150 ,,
	,, 17	,,	45 ,,
	Total.....		6 h. 10 m.

The comparison spectrum of iron was obtained from a single brilliant spark between iron terminals connected with a powerful coil and battery of Leyden jars immediately before the first day's exposure.

Fig. 1.

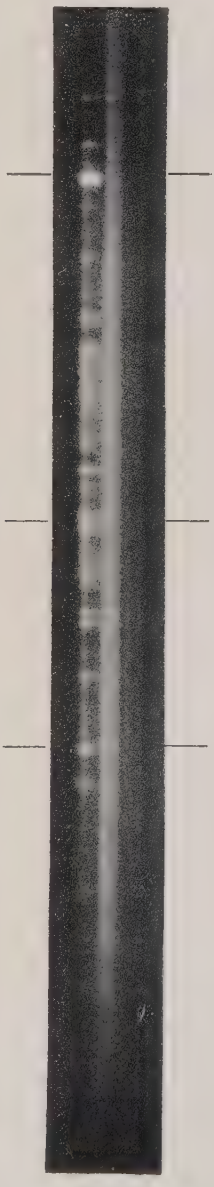

Fig. 2.

Eleven selected iron lines were carefully measured with the Toepfer micrometer. A least-square solution with Hartmann's formula gave

$$\lambda = 2180{\cdot}30 - \frac{181854{\cdot}2}{n - 128{\cdot}8971}$$

(λ_0) (C) (n_0)

of which the residuals respectively were

λ.	Resid.	λ.	Resid.
4063·72.....	−0·03	4404·79.....	−0·15
4171·82.....	−0·02	4476·34.....	0·15
4118·90.....	0·18	4529·1	0·30
4143·85.....	−0·16	4872·25.....	0·35
4260·61.....	−0·06	4957·50	−0·18
4325·88.....	−0·10		

In determining the wave-lengths of the lines in the spectrum of η Argus the above formula was not used, as the representation did not seem sufficiently exact nor could the whole spectrum be conveniently measured at once.

The attached table shows the subdivisions of observation and computation. The above value of λ_0 was retained in the computations, but n_0 and C were determined separately for each block. The means of the micrometer readings are corrected for the carefully determined errors of the screw.

It will be noted that we get for the wave-lengths of the hydrogen lines the following results:—

	Observed.	Known.	K − O.
H_β	4863·38	4861·49	−1·89
H_γ	4343·71	4340·66	−3·05
H	4105·08	4101·85	−3·23

As there is no symmetry between the time of exposure of the plate to the iron flash and to the star-spectrum, we cannot suppose this displacement to be necessarily due to motion of the star; it is more probably due to change of temperature, &c., in the spectroscope. The wave-lengths given in the separate column are corrected for displacement so as to bring out the wave-lengths of the hydrogen and other lines at their true values.

The wave-lengths of the corresponding bright lines in the spectrum of Nova Aurigæ as observed at the Lick Observatory or Potsdam,* are given in the adjoining column, and the agreement is very remarkable.

The photograph with the object-glass prism was taken in 1899, January 14, with an exposure of one hour. The star was trailed to and fro for 0·5 mm., the guiding being done by a neighbouring star viewed in the guiding telescope. The original negative is enlarged 5 diameters in the plate sent (fig. 2, Plate 2).

* Scheiner's (Frost) 'Astronomical Spectroscopy,' p. 287.

The wave-lengths given in the object-glass prism table were derived from careful measures which were converted into wave-lengths by Hartmann's formula and the known wave-length of the hydrogen lines.

The wave-lengths resulting from the object-glass prism are naturally far less reliable than those from the slit spectroscope.

From the very exact agreement between the spectrum of η Argus and that of the Nova Aurigæ, it appears that whatever the causes of the origin of the Nova in Auriga, very similar causes have probably produced the historical changes in the brightness of η Argus.

Table.

Spectrum of η Argus. Measures from slit spectrograph.						Corresponding bright lines in spectrum of Nova Aurigæ.	η Argus (objective prism).	
Comparison. Micrometer. R.	Spectrum. Fe.	Spectrum of η Argus.			λ Corected for displacement.	P = Potsdam. L = Lick. λ	λ	Int.
		Micrometer.	λ	Int.				
63·4193	4957·68	...	...	...	...	...	5018·2	2
		62·6624	4925·9	6	4924·2	P 4923	4924·5	4
		61·1187	4863·38 Hβ	40	4861·49	P 4862 Hβ	4861·49	40
		59·8889	4815·6	2	4813·5	...	4811·6	1
54·6904	4630·90	57·5872	4730·5	2	4828·2	...	4727·0	3 br.
	4630·90	...	...	...	...	...	4665·8	3 v. br.
54·4117	4622·00	54·6871	4630·9	4	4628·5	P 4628	4627·6	8
		54·4070	4621·7	2	4619·3	...	—	—
		53·2965	4585·9	7	4583·4	P 4583	4583·4	7
		52·8596	4572·1	3	4569·6	L 4570	—	—
		52·4900	4560·5	6	4558·0	P 4557	—	—
		52·2008	4551·5	7	4549·0	L 4549	4552·2	—
		51·6428	4534·4	4	4531·8	P 4530	—	—
		51·2971	4523·9	5	4521·3	P 4520	4518·8	v. v. b.
		51·0199	4515·6	2	4513·0	—	—	—
		50·7851	4508·6	2	4506·0	—	—	—
		50·5527	4501·7	1	4499·1	—	—	—
		50·2154	4491·7	4	4489·1	L 4490	4487·7	5 v. br.
		49·6058	4474·0	1	4471·3	$\frac{L+P}{2}$ 4472	4472·4	—
		49·4519	4469·5	1	4466·8	—	—	—
		49·1225	4460·1	2	4457·4	—	—	—
		48·9977	4456·5	2	4453·9	—	—	—
		48·7287	4448·9	2	4446·2	P 4445	—	—
		48·5516	4444·0	2	4441·3	—	4441·6	—
47·5260	4415·33	47·5599	4416·3	10	4413·6	P 4417?	4414·0	—
47·1436	4404·94	...	...	...	...	...	...	10
47·1424	4404·94	...	...	...	...	...	4395·8	3
46·3547	4383·72	45·4700	4360·7	9	4357·5	..	4360·3	1
44·1345	4325·98	45·1883	4353·3	6	4350·2	L 4355	4354·5	20
43·4232	4308·02	44·8215	4343·71 Hγ	10	4340·66	L 4340 Hγ	4340·66	20
43·1062	4299·44	...	...	...	...	...	4300·9	4
42·9005	4294·32	42·6890	4289·1	9	4286·1	...	4286·0	10
42·4178	4282·54	42·2246	4277·7	3	4274·7	...	4275·3	3
41·9777	4271·68	—	—	—	—	...	—	—
41·5002	4260·67	—	—	—	—	—	—	—
41·0769	4250·65	40·8929	4245·8	7	4242·7	...	4242·4	7
40·0791	4227·65	40·4445	4235·3	5	4232·2	...	4232·2	7
39·7487	4219·52	—	—	—	—	—	—	—
36·3117	4144·01	...	...	...	...	P 4176	4174·8	6 br.
35·1127	4118·72	...	...	...	...	L 4166 P 4158	4164·4	—
32·7827	4071·84	34·5930	4108·2 {	Sus-	} 4105·0	—	—	—
32·3631	4063·75	34·4388	4105·08 Hδ	pected 3	4101·85	L & P Hδ	4101·85	8
—	—	—	—	—	—	—	4067·0	1

br = broad ; v. br. = very broad.

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The attention of Fellows is called to the fact that ladies are only admitted to the Ordinary Meetings of the Society by special invitation of the President, sanctioned by the Council. The invitations are issued at the commencement of each Session.

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